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GLANDLESS COTTON

Its Significance, Status, and Prospects

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Proceedings of a Conference
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Agricultural Research Service
United States Department of Agriculture
and
National Cottonseed Products Association, Inc.

TRIBUTE TO KARL F. MATTIL

It is especially fitting that the participants in this conference pay tribute to Dr. Karl F. Mattil who died on October 4 of this year, following a short illness. Karl was Director of the Food Protein Research and Development Center of Texas A&M. He helped to plan this conference, and his name is listed on this morning's program.

He was truly a great man who always demanded too much of himself. He was like a brother to most of us who were privileged to work closely with him. One instinctively knew that he had great strength of character and sense of purpose. We could love him and respect his thinking and capability with full knowledge that he might, and did, sometimes, vigorously disagree with us. He had unlimited loyalty and leadership, but he never knew the meaning of guile or restraint of frankness. His understanding and his love of all mankind were deeply ingrained within him, but he detested stupidity and intellectual dishonesty or intellectual laziness. We all had the opportunity to be better men and women because of our association with him.

--Garlon A. Harper
National Cottonseed Products Association

FOREWORD

An exciting new potential for improvement of the value of cottonseed was widely acclaimed in 1959 when Dr. Scott McMichael reported the development of cotton with no glands and essentially zero gossypol content in the seed.

After nearly two score years of sometimes rewarding and sometimes frustrating scientific, technological, and commercial activity, a vast volume of meaningful information has been developed. Cotton breeders have begun to approach and/or achieve the development of varieties which are equal or superior to reference glanded variety standards in fiber yield and quality. The need to attempt a realistic assessment of the significance, status, and prospects for extensive commercial production of these glandless cottons is abundantly apparent. The objective of this conference is to satisfy that need.

The decisions which are now needed should be motivated by economics, and they will be trustworthy only if founded upon scientific and technological data which affect the welfare of each segment of the cotton industry and the historical and potential new consumers of cottonseed products.

A concerted effort was made to design this program to stimulate maximum dialogue between scientists, technologists, breeders and seedsmen, growers, ginners, seed processors, food and feed manufacturers, and economists. The links in this chain are highly dependent upon each other. The fullness of their interaction will significantly affect the degree of the success of this conference.

GENERAL CHAIRMAN

Garlon A. Harper
National Cottonseed Products Association

CONFERENCE COORDINATOR

Shirley T. Saucier
Agricultural Research Service

WELCOME AND PRESENTATION OF SCOTT C. MCMICHAEL

By Philip A. Miller

On behalf of the Agricultural Research Service, U. S. Department of Agriculture and the National Cottonseed Products Association, I am happy to welcome each of you this morning. We have planned what we feel will be an interesting and stimulating meeting on glandless cotton. Our objective is to conduct a realistic and frank assessment of the current significance, status, and prospects for glandless-seeded cotton. In order to accomplish this, we felt it was essential to stimulate maximum dialogue between scientists of various disciplines, technologists, breeders, seedsmen, growers, ginners, seed processors, food and feed manufacturers, marketing specialists, and economists. We are all linked together in our involvement and interest in this topic.

Again, we are happy to welcome you and are looking forward to frank and open exchanges of information and discussions on glandless cotton.

We are very fortunate to have with us today the scientist who developed glandless-seeded cotton. As all of you are aware, of course, I am referring to Dr. Scott C. McMichael. Dr. McMichael consented to show us a few slides about his early work with glandless cotton. First, just a few words of introduction.

Dr. McMichael is from the State of Washington. I understand that he graduated from Washington State University in Agronomy in 1930. He then went on to the University of Minnesota where he completed his doctorate in plant breeding in 1936. He spent a short time with the Soil Conservation Service in South Dakota and then accepted a position with USDA in 1937 as a cotton geneticist and breeder at the Cotton Research Station at Shafter, California.

Scott spent the next 35 years in cotton genetics research. He retired in 1972. His research covered a wide range of subjects, but the one that interests us today is his work on glandless. I do not want to steal Scott's thunder, because he is going to tell us about this early work. However, I do wish to make the point that it took a great deal of hard work, a great deal of perseverance, and a great deal of imagination for Scott to develop the first glandless cotton. His first efforts resulted in a cotton plant that did not have glands on the stem but still had glands in the seed. Most of us would have stopped at that. But Scott visualized the potential value of a glandless seeded type, and kept on looking. He studied primitive, desert-type plants; made hundreds of crosses, carefully examining leaves and cotyledons of thousands of plants, until he eventually found what he was looking for. He officially reported his discovery of glandless-seeded cotton in a scientific article in 1959. He distributed seed of glandless to cotton breeders through the U.S. and the world.

But let's hear about this in more detail directly from Dr. McMichael. It is a pleasure, Scott, to present you to this conference.

DEVELOPMENT OF THE GLANDLESS SEEDED CHARACTER IN COTTON

By Scott C. McMichael

The first glandless mutant which I discovered in cotton was a glandless-stem type. A single recessive gene designated as glandless-one (gl_1) removes the pigment glands from the stems of the cotton plant but the seed remains normally glanded. Glandless-one is of value as a genetic marker only. It did, however, spark the idea of looking for other glandless genes that would reduce or even eliminate pigment glands in the cottonseed. New genes were found that reduced but did not eliminate the number of glands in the seed. Further study, however, showed that if two of these newly discovered glandless genes (gl_2 and gl_3) were combined in one plant, then glandless seed would be produced. Subsequent work by myself and others confirmed this viewpoint and the segregation ratio of 15 glanded to 1 glandless from crosses between normal glanded plants and glandless seeded plants. At least one or perhaps both of the glandless seed genes are from Hopi cotton. This cotton was grown by the Hopi Indians since before Columbian times. The primitive nature of this cotton is shown by its small bolls and spindly stems.

The glands which we observe in seed are embedded in the cotyledonary leaf tissue of the seed embryo. The search for glandless seed genes was greatly facilitated by examining the expanded cotyledonary leaves of seedlings following germination of the seed. Seeds were germinated in greenhouse sand flats. Selections were placed in tar paper pots for later transfer to the field. Seedlings can be examined for cotyledonary glands in the field but this is not practical on a large scale. A glandless seed plant should be gland free though occasionally a gland or two will be found in an axil. A safe index as to whether a given plant is glandless seeded is to examine the stipules (small leaf-like appendages). A gland-free stipule was found to indicate the glandless seed character.

The glandless seed cotton has been released to cotton breeders in this and other countries. Dr. H. B. Cooper continued the glandless breeding program at the Cotton Research Station, Shafter, California, and has reported the development of glandless strains which compare favorably in performance with the current glanded Acala varieties.

INTRODUCTION: THE NEED FOR THIS CONFERENCE

By Garlon A. Harper

At the outset of this conference it may be helpful to think together for a few minutes on the need for the conference and the necessity to structure the program into the distinctive nature which has been attempted.

Perhaps, in the past we may have had some tendency to go our separate ways without a common understanding and a united effort. If so, there is every reason to correct that error.

Since Dr. Scott McMichael first developed pigment gland-free genotypes of cotton, too many research and development dollars and too many man-hours of effort have been invested for us to hold our present diverse opinions of value and practicality. Some appear to be saying that the egg is golden, others believe it is infertile, and many of us are probably still wondering whether the chicken or the egg comes first. We simply have not been adequately communicating with and understanding each other despite our volumes and volumes of publication and comment. During the two days of this conference we must establish real communication by listening and reacting as well as talking. The time has come to either get about the business of producing glandless cottonseed in significant volume, determine what additional information, if any, is needed, or fold up our tents and admit to ourselves that it was just another grand experiment.

I made reference to the structure of this conference as being distinctive. On paper, it truly is. It brings together for factual interaction widely diverse disciplines of science and technology, and the distinctly separate, although interdependent, segments of industry. We shall hear cotton breeders review their progress. Information on values and opportunities will be updated. Problems of production and handling will be reviewed. Hopefully, each of us shall see the situation from the vantage point of others as well as that which is peculiarly our own. We can well begin with the premise that glandless cottonseed will be produced only if each affected segment sees a reasonable opportunity for monetary gain.

Thus, we should relearn the old lesson that there is no free lunch and that the basis of motivation and action depends upon prospects for improvement in the economic position of each. Some examples: The grower is not going to plant glandless varieties unless he believes they will make more profit than available glanded varieties; the processor cannot be expected to pay an arbitrary premium for glandless seed which is not based on sound expectation of economic return; and the consumers of glandless cottonseed products will not buy on a preference basis unless they are convinced of an advantage.

So, we come to seek information and reason together. If we do our work well, we can establish a foundation on which we can build with confidence.

If we approach our deliberations with narrow vision, or unsupported prejudice, or unrealistic idealism, we shall make little progress and we shall do ourselves and those who follow us a disfavor.

Some of us believe that glandless cottonseed will be and must be widely grown someday regardless of what we do now. But, someday is not good enough today. I submit to you that in all good conscience we must make every effort at this conference to arrive at the most realistic appraisal which available information will support. I have confidence that you will do this.

Our deliberations here will be incomplete if we fail to give some recognition to the fact that gossypol and gossypol-like pigments can be deleterious to animals and are to be treated as such. Oil processing removes gossypol, and meal processing inactivates a high proportion of the substance. Further, meal use information has been developed to the point that there is not danger of adverse physiological effects when proper feeding practices are observed. These pigments are not public health hazards.

Nevertheless, we must be aware that the present regulatory and consumer activist climate is such that gossypol in cottonseed may someday be severely challenged. Glandless cottonseed avoids that challenge. Increases in gossypol content of cottonseed tends to increase the risk of that challenge.

We need to pause here and place in proper perspective the subject of toxins and toxicity. Frank M. Strong, Chairman of the National Academy of Sciences Subcommittee on Naturally Occurring Toxicants in Foods, did this quite meaningfully. He said, "It is . . . mistaken to demand a food supply containing no harmful substances; all substances are toxic in some degree and therefore potentially harmful." So, toxicity actually depends, among other factors, upon the degree and nature of the toxic properties of a substance and upon the volume of intake or exposure. However, we see a disturbing trend toward disregard of this scientifically sound principle in the actions of regulators who have become the unelected fourth branch of the Federal Government and the volatile consumer activist groups.

Despite all we know today about gossypol and how to handle present levels safely in cottonseed products, I would not want to be faced with the difficult task of obtaining FDA clearance for cottonseed if it were a new food commodity. It might never be approved by that Agency as a safe food additive and the cost of trying would be tremendous. Fortunately, it comes under the classification of Generally Recognized as Safe. But, GRAS substances are being constantly reviewed and a given product can be removed from that classification.

I think you must ask yourselves how long Government will tolerate the production of food and feed from cottonseed containing gossypol. I especially believe that those who would seek to increase the gossypol content of cottonseed as a deterent to insect damage must seriously consider whether the benefits they hope to gain are worth the risk of loss of a food and feed market for cottonseed.

Your participation in this conference indicates that you join us in anticipation of a mutual sharing of information and understanding of the needs, problems, and opportunities of all those who are affected. I hope that you will find that interaction to be challenging, stimulating, and productive.

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CURRENT STATUS AND FUTURE MARKET POTENTIAL FOR COTTONSEED

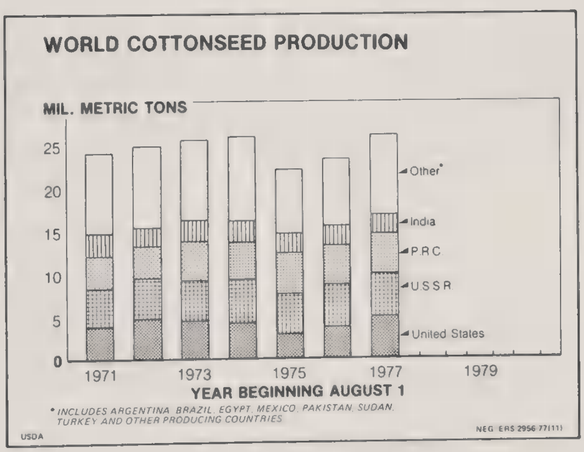
By George W. Kromer

Cottonseed is one of the leading oilseeds of the world, accounting for roughly one-tenth of the global production of edible vegetable oils and protein meals. But because many countries retain much of their output for home consumption, cottonseed products represent only about 3 percent of the world's trade in edible oils and protein meals.

World Production of Cottonseed

World cottonseed production in 1977/78 is estimated at a record 26 million metric tons, up a tenth from last year and slightly exceeding the previous high set in 1974/75. Production thus far in the 1970's has fluctuated between 22 and 26 million tons, averaging about 24 million tons. The United States accounts for 40 percent of this season's increased output as relatively high cotton prices at seeding time encouraged farmers to expand plantings.

The world cotton area for 1977/78 is estimated at around 33 million hectares compared with 31 million last year. Cotton production is placed at an estimated 65 million bales (480-pound set weight bales), a new record high and 7 million bales above 1976/77.



The United States is one of the world's largest producers of cottonseed, along with the USSR and the People's Republic of China (PRC). These three countries and India account for approximately two-thirds of the world's cottonseed production. Most cottonseed is crushed in the producing countries and only negligible quantities move in world trade as seed.

World Edible Vegetable Oil Exports

More than one-third of the world's edible vegetable oil output of around 36 million metric tons moves in world trade. Soybean and oil exports are by far the largest in volume, with nearly one-half of production going into world markets either in the form of beans or oil.

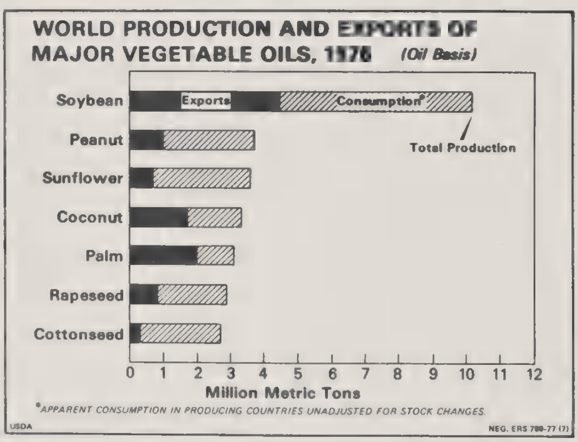
Palm and coconut oils are also high volume export commodities, accounting for two-thirds and one-half, respectively, of world output. Malaysia, the world's leading palm oil producer, exports over 95 percent of its output. Peanut and rapeseed exports each account for a fourth of their output.

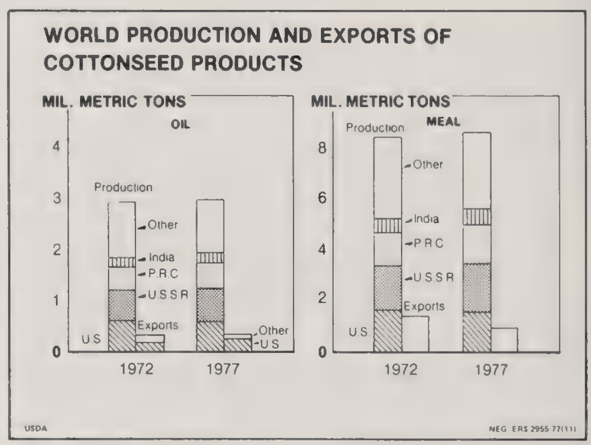
A relatively low volume of cottonseed oil moves in world trade, but it is an extremely important market for the U.S. cottonseed industry.

World Trade in Cottonseed Products

World production of cottonseed oil in 1977 is estimated at about 3 million metric tons, with the United States contributing more than one-fifth to the total. World exports of cottonseed oil at 0.4 million tons comprise only 12 percent of the total production. The United States exported 0.3 million tons, thus accounting for 75 percent of the cottonseed oil moving into world markets. Other countries exporting small quantities of cottonseed oil include the USSR, Sudan, and Nicaragua.

The volume of cottonseed meal moving in export channels is also fairly small--totaling 0.9 million tons in 1977 or about 10 percent of the world's estimated output of nearly 9 million tons. The world's leading exporters are Turkey, Sudan, India, Argentina, and Brazil. The United States produces about one-fifth of the world's cottonseed meal, but we ship only negligible quantities overseas.





U.S. Cotton Situation

Because cottonseed is a byproduct of lint production, it is essential to briefly examine the U.S. cotton situation.

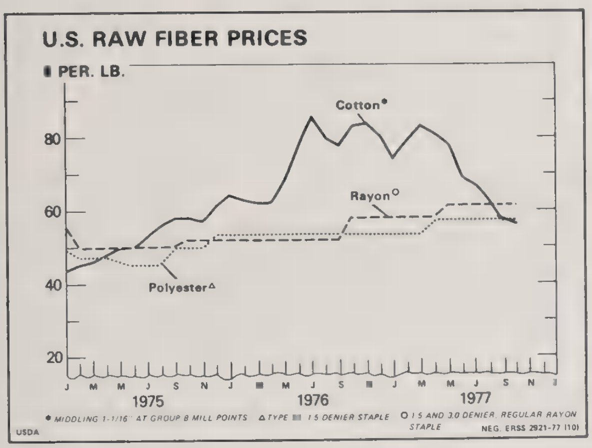
The 1977 cotton crop was estimated at 13.8 million bales as of November 1, 3-1/4 million more than last year. But with smaller carryover stocks last

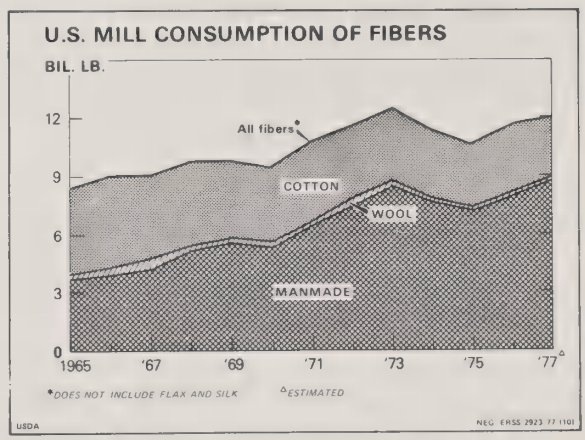
August 1, the total 1977/78 supply of 16.8 million bales is up only 2-1/2 million.

Cotton exports are expected to drop moderately below the 1976/77 level of 4.8 million bales--possibly to around 4.4 million bales. U.S. cotton mill activity is also sluggish but is expected to gradually improve, enabling cotton consumption this season to about match the 1976/77 level of 6.7 million bales. With total anticipated disappearance below production, carryover stocks next August may increase to 5-1/2 to 6 million bales. Stocks last August were 2.9 million bales--a 25-year low.

U.S. textile manufacturers in November were paying around 55 cents per pound for Middling 1-1/16-inch cotton. This was slightly below the price they were paying for polyester staple and moderately less than they were paying for rayon staple. As a result, cotton is enjoying its strongest competitive position since early 1975.

U.S. mill consumption of fibers in calendar 1977 is estimated at around 12 billion pounds, up 3 percent from last year. With tight cotton supplies and high prices relative to manmade fibers early in the year, cotton's share of this growing market is slipping. Cotton may account for a record-low 26 percent of total use this year, compared with 29 percent in 1976. However, cotton's share is expected to rebound in 1978, reflecting larger supplies and more competitive prices.





Near record textile imports are capturing a growing share of the U.S. market. Imports of cotton and wool manufactures now account for about one-fifth and over one-half, respectively, of products sold over retail counters. Textile imports represent about 6 percent of the domestic manmade fiber market.

Cotton Industry Research Funds

Cotton producers are seeking to bolster demand for their products by increasing contributions for research and promotion. Under provisions of the amended Cotton Research and Promotion Act of 1966, producers voted last December to contribute up to 1 percent of the value of each bale sold, in addition to the previous $1 per bale assessment. The supplemental contribution has been set at four-tenths of 1 percent for the 1977 crop, meaning an additional assessment of $1 per bale or so. As a result, Cotton Incorporated has budgeted

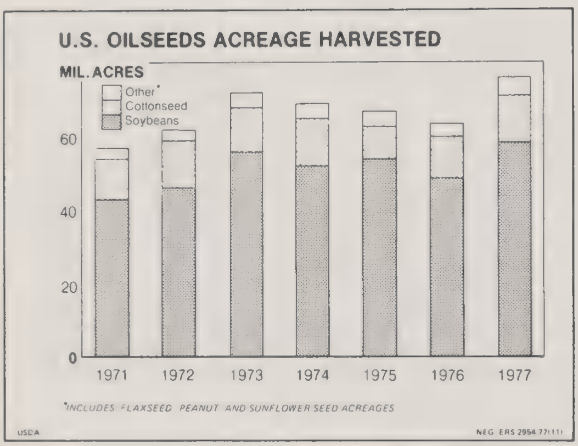
$20.5 million for research and promotion in calendar 1978, compared with $14 million this year.

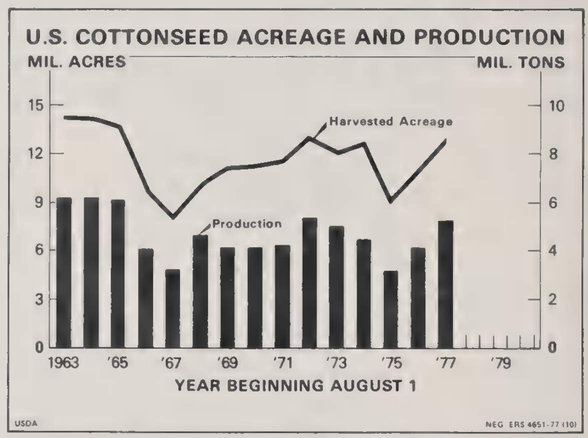
U.S. Oilseed Acreage

The United States harvested 76 million acres of oilseeds this year, 12-1/2 million more than in 1976. More than two-thirds of the increase (9 million acres) were in soybeans. Cottonseed acreage was up 21 percent from 1976. Sunflowerseed acreage doubled this year--going from less than 1 million acres in 1976 to over 2 million in 1977. Flaxseed acreage also increased sharply, while peanut acreage remained about unchanged.

Cottonseed harvested area totaled 13 million acres this year, about 2-1/3 million more than in 1976. This is the second consecutive year in which cotton producers expanded acreage, spurred by relatively favorable prices.

The 1977-crop cottonseed yield per harvested acre is estimated at 818 pounds compared with 760 pounds in 1976. This has resulted in a cottonseed crop of 5.4 million short tons (November 1 estimate), up 30 percent from 1976 and 68 percent above the short 1975 crop. The cottonseed yield per acre is more than 1-1/2 times the lint yield of 503 pounds.





Cottonseed prices are down sharply this season, reflecting the large cottonseed supply coupled with generally weaker prices for most oilseeds. Prices received by farmers for 1977/78 crop cottonseed probably will average around $75 per ton, compared to $103 last season. Prices received for cottonseed most seasons cover the farmer's cost for ginning his cotton. But cottonseed prices this year are well below ginning costs.

The total value of the 1976 U.S. cotton crop was $3.3 billion, while cottonseed was valued at $428 million--about 13 percent that of cotton.

Cottonseed Crush

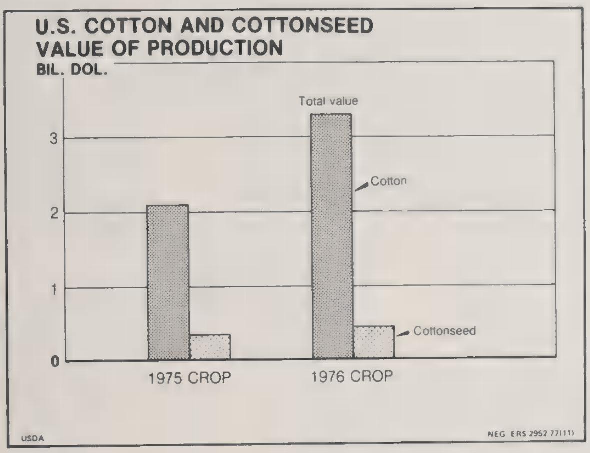
Between 90 and 95 percent of the U.S. cottonseed crop is processed for oil and meal. There are approximately 100 cottonseed crushing plants to handle the crop. Usually not more than 5 percent of the seed is required to plant the next year's crop.

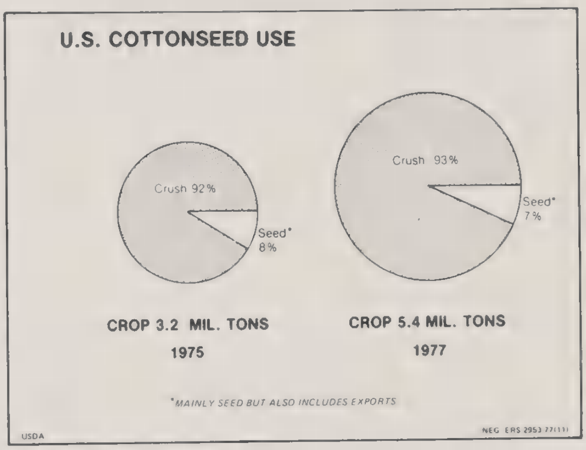
Cottonseed crushings from the 1977 crop are estimated at 5.0 million tons, up 1-1/2 million from the 1976-77 season. A crush this size will yield about 1.6 billion pounds of crude cottonseed oil and 2.3 million tons of meal.

During the 1976/77 crushing season a ton of cottonseed yielded 326 pounds of crude oil (16 percent), 898 pounds of meal (45 percent), 177 pounds of linters (9 percent), and 524 pounds of hulls (26 percent). About 75 pounds (4 percent) were lost in the process.

Looked at in terms of value of products per ton of seed crushed, oil and meal each accounted for $83 per ton of the total product value of $189. Oil and meal combined contributed 88 percent to the total value of products at the cottonseed crushing plants. This points up the importance of the oil and meal markets.

Cottonseed hulls are used primarily as a feed for livestock, usually added back to the meal. Cotton linters go into the felting and chemical trade and are used in a wide variety of products. In this paper I am concentrating on the cottonseed oil and meal markets.





Cottonseed Oil Markets

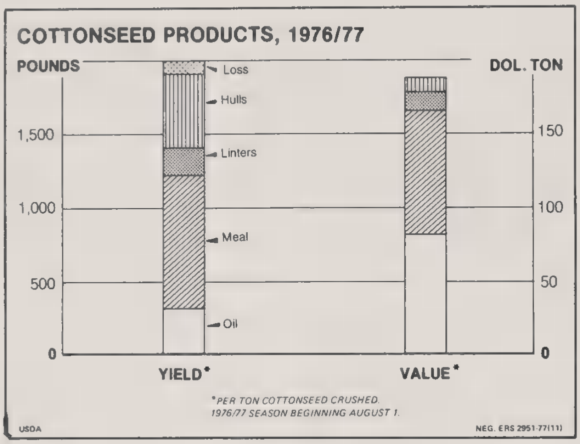
In the United States soybean oil is the leading edible vegetable oil, followed by cottonseed oil. Total edible vegetable oil consumption has risen from about 30 pounds per capita in the mid-1960's to a record 49 pounds in 1976. Soybean oil use nearly doubled during this period, from 19 pounds to 34 pounds. Cottonseed oil use shrank, dropping from 7 pounds to 2 pounds per person. Smaller supplies of cottonseed oil at premium prices compared to soybean oil, the quality of which has been improved, have reduced domestic demand. Thus, the cottonseed oil market has largely shifted overseas where the product is still a preferred premium oil in some parts of the world.

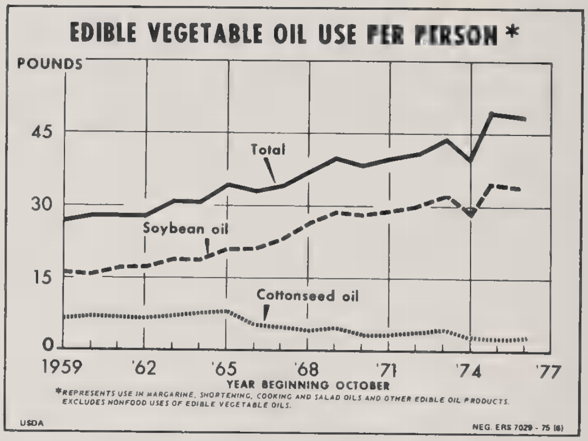
Cottonseed oil is used mainly as a cooking and salad oil and in the manufacture of margarine, shortening, and other edible products. Because of its byproduct nature, cottonseed oil supplies are inelastic whereas soybean oil, palm oil, and sunflowerseed oil can adjust to changing consumer demands and economic conditions.

The total use of cottonseed oil has dropped sharply from about 2.0 billion pounds in the 1965 season to 1.3 billion last season. Most of the decline occurred in the late 1960's and early 1970's.

Domestic use of cottonseed oil fell from 1.7 billion pounds in 1965 to 0.7 billion this past season--a drop of 1 billion pounds. Consumption declined 600 million pounds in cooking and salad oils, 300 million in shortening, 75 million in margarine, and 50 million in nonfood uses. Soybean oil, corn oil, palm oil and peanut oil all made inroads into the traditional cottonseed oil domestic markets.

While U.S. consumption of cottonseed oil was declining over the past decade, exports were gaining, and this partly offset losses in the domestic market.





Export Major Outlet

As mentioned earlier, the United States is the only major world exporter of cottonseed oil.

U.S. exports have trended upward rather steadily from 139 million pounds in 1968 to 690 million in the 1976 season. An exception was in 1975/76 when cottonseed oil supplies were short. Egypt, Venezuela, and Western Europe are the major overseas markets for U.S. cottonseed oil.

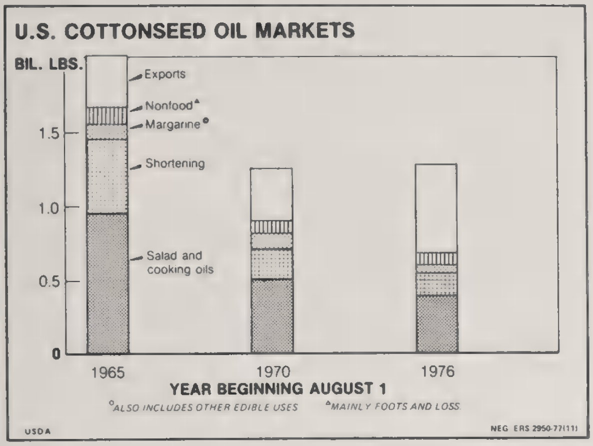
During 1976/77 Egypt imported 429 million pounds of U.S. cottonseed oil, accounting for 62 percent of our total exports that year. This has been a rapidly expanding market since cottonseed oil is a preferred commodity in Egypt.

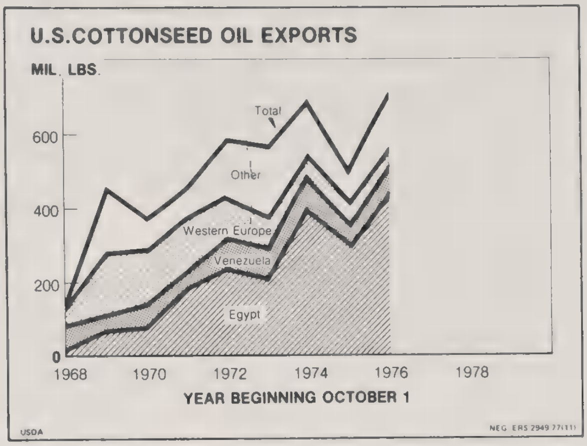
Price Trends

Cottonseed oil prices (crude, Valley) have fluctuated widely over the past 5 years with the annual average varying between 16 and 33 cents per pound. During the period, the price premium for cottonseed oil over soybean oil (crude, Decatur) averaged about 2 cents per pound. In the 1976/77 season, cottonseed oil prices averaged 25 cents compared with 24 cents for soybean oil--a price spread of 1 cent per pound. In November 1977 cottonseed oil was priced at about 22 cents and soybean oil was 21 cents.

One of the principal reasons why cottonseed oil has been able to maintain its price premium over soybean oil, in spite of a declining domestic market, is the sharp pickup in export demand that I discussed earlier.

In the years ahead, I believe it will become more difficult for cottonseed oil to command a 2-cent-per-pound price premium over soybean oil in the U.S. market because of increased competition from soybean and other edible oils--including imported palm oil. If the industry has hopes of recapturing some of its traditional domestic markets, cottonseed oil must be priced more closely to soybean oil than in the past.





Cottonseed Meal Markets

The United States will consume about 22 million tons of high protein feeds (44 percent protein, soybean meal equivalent) in 1977/78. Soybean meal will account for about two-thirds of the total and cottonseed meal nearly one-tenth. Animal and grain proteins largely account for the balance.

More than 2 million tons of cottonseed meal will be produced and consumed this season, primarily in livestock feed. The volume of cottonseed meal available for feeding each year naturally varies with cottonseed production.

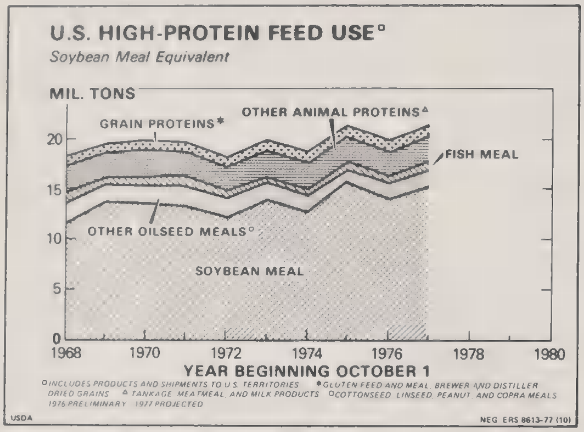
About one-half of the 2 million tons of cottonseed meal fed in the United States goes to beef and dairy cattle. Hog feeding utilizes another 10 percent and other livestock 15 percent. Thus, livestock feeding accounts for an estimated 75 percent of cottonseed meal utilization. Poultry feeding (broilers, hens and pullets, chickens, and turkeys) accounts for the remaining 25 percent.

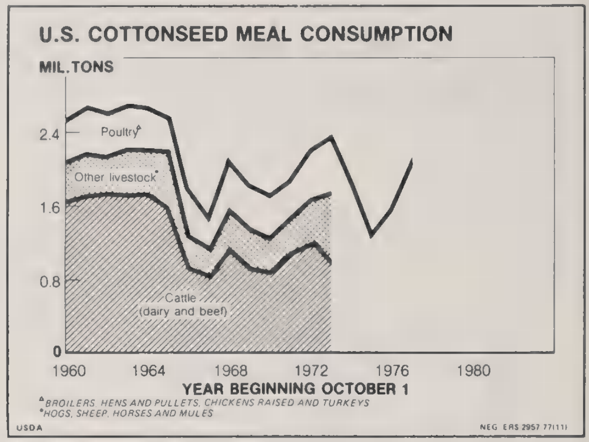
Cottonseed meal prices (41 percent protein, Memphis) during the 1976/77 season averaged $176 per ton, about $24 below the average price for soybean meal. Cottonseed meal typically sells at a $10-to-$15 discount to soybean meal since its protein content is lower and its feed use is more limited.

Factors Affecting Future Production of Cottonseed

Future supplies of cottonseed will mainly be determined by the competition between cotton and synthetic fibers. With the increased cost of petroleum--the major base for synthetic fibers--and other energy costs, the world's fiber use may be altered if cotton maintains its competitive position. The U.S. farmer can expand cotton production to meet the growing demand for fibers if the economic incentive is provided.

Markets for glandless cottonseed products will expand as increased quantities of the seed become available to attract the food processing industry. An adequate and dependable supply of raw materials is of prime importance to the food industry.





Commercial production of glandless cottonseed has been slow in developing mainly because of the lack of economic incentive for cotton growers. Glandless seed varieties are required that do not affect the overall quality of the lint or reduce lint yields per acre. Otherwise a price incentive is needed to obtain glandless cottonseed production.

Future Cottonseed Meal Markets

Cottonseed meal is largely an untapped source of protein for edible uses. Food use has been limited by the presence of pigment glands containing the pigment gossypol. Research on processing has developed the liquid cyclone process for removing gossypol from glanded cottonseed, but I understand it is not in commercial operation as yet. Also, research in breeding has developed glandless cotton. This enables cottonseed meal to be marketed as defatted flour, concentrates, and isolates--similar to products now manufactured from soybean protein.

USDA projections for expanded use of edible soybean protein have been optimistic, but currently only about 2 to 3 percent of soybean meal production is processed for edible uses. Growth of protein meal use in the food market has been limited by some undesirable flavors, flatus (gas generated in the intestinal system), and problems with color and texture in some uses. Consumer tastes and acceptance of new products change very slowly, but improved processing technology likely will expand this market.

Livestock feeds (particularly cattle) likely will continue to be the major market outlet for cottonseed meal in the foreseeable future. But with the production of gossypol-free meal, the feed market will broaden as the meal can be fed to all classes of livestock and poultry.

Future Cottonseed Oil Markets

The export market likely will continue to be the major outlet for cottonseed oil. But the heavy dependence upon one country (Egypt) for the bulk of U.S. exports leaves this market vulnerable should that country shift to alternative sources or other edible oils.

If cottonseed oil is to regain some of the lost domestic markets, its traditional price premium over soybean oil may have to narrow or disappear. Experience has taught us that lost oil markets are difficult to recapture. Competition likely will stiffen among the edible oils, as most projections indicate that supplies of soybean, sunflowerseed, and palm oils will continue to increase.

IMPACT OF GLAND PIGMENTS UPON TRADITIONAL COTTONSEED PROCESSING PROCEDURES

By Leslie R. Watkins

The best way for me to describe processing of glandless cottonseed is to make a comparison with processing of normal glanded cottonseed.

Much energy and heat is used to bind the gossypol to the meal so that the meal will not have excessive free gossypol and the oil produced will not revert in color by reaction of the gossypol with the crude oil. This cooking also denatures the protein as it reduces the free gossypol in meal.

We would expect all glandless cottonseed to be processed by direct extraction while the glanded varieties would be extracted by direct extraction or following pre-press removal of two-thirds of the oil. My comparison will be based on pre-press for glanded cottonseed and direct extraction for glandless cottonseed at approximately 300 tons/day capacity.

First change in processing is at rolling stage. Processing of glanded cottonseed usually requires the addition of moisture for proper rolling to rupture the glands containing gossypol. Five high crushing rolls are used for this rolling. By comparison, glandless cottonseed processing would be accomplished by light rolling to form extractable flakes. Flaking rolls would be used for this function, utilizing approximately 50 percent of the energy required for glanded cottonseed processing.

For glanded cottonseed, cooking is required prior to pre-press to coagulate the albuminous protein and bind as much gossypol to the meal as had been released in rolling. For the 300 ton/day plant, approximately 1500 lbs./hr. steam would be required.

By comparison, glandless cottonseed processing requires only light heating prior to rolling to optimize flaking with low fines content. The steam required would be less than 50 percent of that required for binding the gossypol.

Next the pre-press operation for glanded cottonseed would not be required for glandless cottonseed. This would save more than 300 H.P. and much costly maintenance.

A larger extractor is required for direct extraction of glandless cottonseed because diffusion is slower. Cells containing the oil are still intact and the hexane has to penetrate these cell walls.

Another factor is solvent flow. Although three times as much oil is removed in direct extraction, the solvent flow is only doubled and the heat required to recover the solvent is increased only 20-30 percent because much of the hexane can be evaporated from the miscella utilizing heat from the meal desolventizer vapors. Larger evaporator and strippers are required for the increase in extracted oil unless miscella refining is included in the pre-press operation. When miscella refining is a part of the pre-press solvent plant, the evaporator and stripper are almost the same.

The justification for miscella refining with glanded cottonseed is greater. Good bleach color of oil is difficult to maintain after the first few months of each season, as gossypol becomes more difficult to bind to the meal. With glandless cottonseed much of the advantage for miscella refining is lost because the normal excess caustic required to react with the color no longer enters into the picture. Miscella refining still will be more efficient because the entrained neutral oil in soapstock can be much less.

Factors still unknown may appear in the usage of glandless cottonseed meal.

The cooking used to bind gossypol may be hiding good or bad nutritional factors. Enzymes that are completely inactivated when binding gossypol may become a factor. Urease in cottonseed seems to remain active under the mild conditions of desolventization required to maintain highest protein solubility.

Final utilization will play an important part in the processing that is required.

We are now waiting for the nutritionists to advise the processors what additional treatment would be desirable so that we may optimize our process to fit nutritional needs.

DISCUSSION

A. L. BOWLING Could you put in perspective what is the total amount of energy used in a cottonseed plant and the proportion of savings when glandless seed is used in relation to the total consumption of energy? In general terms at least.

L. R. WATKINS You have asked a most difficult question because we find that with our plants we may vary as much as 50 percent between plants. In the general terms that you have asked, I would say that the energy requirements for the glandless variety are approximately 50 percent less from the rolling stage to the solvent plant if we are using a glandless variety as compared to a glanded; although that same type difference may appear in other processes. If we are comparing just the one change, we are talking about approximately 50 percent.

W. H. MARTINEZ Are you suggesting that, if we had glandless, we would essentially be turning toward a complete solvent extraction operation? Is this necessary? What are the energy comparisons that can be made, including the energy involved in the production of hexane, between screwpressing and direct solvent extraction for glandless alone.

L. R. WATKINS For glandless alone, we will actually have a hexane flow of double to remove three times as much oil. We do not expect any increase in hexane loss. The same amount of meal would be passing through the solvent plant. The extraction is going to take a little longer because we have not ruptured all the cell walls and we are going to have to permeate the cell walls to get to the oil. But energy requirement from pre-press operation forward or from the roll forward, we would expect about half. Solvent required in solvent plant would not result in any increase in energy required for evaporating hexane because we would be recovering heat from the vapors of the meal desolventizer. When we are using pre-press operation, we have an unbalance. We have surplus heat

available in the vapors from the meal desolventizer that we cannot take advantage of. There is a more proper balance when we have a direct extraction.

W. H. MARTINEZ I am afraid I did not make myself clear. Is there any role for a screwpress operation with glandless?

L. R. WATKINS Certainly, no problem. No difference.

W. H. MARTINEZ How would a straight screw-press operation compare energy-wise with a direct solvent extraction operation? Is there any advantage of one process over the other?

L. R. WATKINS I would say yes. I would say direct extraction would have an energy personnel and maintenance advantage over screwpressing.

C. R. RATHBONE Les, I presume you started with rolling. You have assumed that the preparation, delinting, and all prior to that would be the same, and that we would be making feed grade meal instead of an edible meal. Right?

L. R. WATKINS Yes.

C. R. RATHBONE What if you were making an edible meal with double or triple hulling and so forth in preparation for getting whole meats that are clean. Have you made any comparison?

L. R. WATKINS I am actually comparing if every cottonseed oil mill in the world were converted to glandless. We would then have more cottonseed meal produced than would be required for human food and it would go into pet foods, chicken and a lot of other products. Let us say into a lot of other feeds that cottonseed is only being used to a minor degree now. A comparison of the much higher grade that would be required for producing for the edible market versus the feed market is a much more complex situation. This processing situation could, I feel, best be handled by taking a plant, and if you want to call it "skimming the cream off the top." This would be my perferred method.

G. C. CAVANAGH Do you have any thoughts about the problems with storage, insects, birds and rodents comparing glandless versus glanded?

L. R. WATKINS Well, I guess the only observation we had was at one stage of glandless for a brief moment they thought the glandless cottonseed plant was attacked by insects that would not attack the glanded, but this did not turn out to be true. They thought that the gossypol in the plant would protect the plant from insects and that turned out to be not true. So, I do not expect any difference. This is out of ignorance rather than anything else.

Is there anybody here who would know of any difference that we might expect? Does the gossypol in the seed protect it from anything? If not, then thank you.

SIGNIFICANCE OF GLAND PIGMENTS IN PROCESSING, STORAGE, HANDLING, AND UTILIZATION OF COTTONSEED OIL

By N. J. Smallwood

INTRODUCTION

Anyone with experience in handling and processing regular cottonseed oil can only be positive about the potential availability of consistently light colored oil produced from glandless cottonseed. The wide variation in and unpredictability of regular crude cottonseed oil color presents an ongoing quality and profitability challenge to the vegetable oil processor. And, that is one of the reasons why soybean oil has emerged over the last thirty years as the dominant edible oil.

In assessing the potential impact of glandless cottonseed oil, it appears essential to compare the oil to both regular cottonseed oil and soybean oil. For, if the oil aspect of glandless cottonseed is to make a significant impact on future development and availability, it must be both superior to regular cottonseed oil and be more economically competitive with respect to soybean oil.

With growing concern over the cost and availability of energy, the assessment of glandless cottonseed oil is appropriately timed. Energy requirements for processing soybean oil are greater than for cottonseed oil.

Information about and experience with glandless cottonseed oil at this time are quite limited. Thus, it has been necessary to make several assumptions and projections about the expected performance of glandless cottonseed oil.

UTILIZATION

There are several sources of edible fats and oils available to the processor for making any given finished product. Each source yields oil of differing composition and characteristics. Partial or complete substitution of oils is possible for most finished products. The particular oil selected for a given finished product is a function of physical and chemical characteristics, availability and price (Bailey, 1948). For many years, cottonseed oil occupied the dominant position with respect to all three selection criteria. By the mid 1940's, soybean oil production surpassed cottonseed, and the lead has been steadily increased. According to the Agricultural Research Service of the USDA, for the 1976 crop year, total cottonseed oil production was 1.2 billion pounds compared to 8.6 billion pounds for soybean oil.

The crude price advantage of cottonseed oil compared to soybean was lost in the late 1930's. In recent years, the crude price differential of cottonseed over soybean oil is about $0.015 per pound.

TABLE 1.--Comparison of Oil Characteristics (Typical Analyses)

Analyses	Regular (Glanded) Cottonseed Oil	Glandless Cottonseed Oil[a]	Soybean Oil
Refined Color	6.0	3.2	7.4
Bleached Color	2.8	1.5	1.9
Deodorized Color	2.4	0.9	1.0
Iodine Number	97-112 (108)	108	120-141 (130)
A.O.M. Stability (Hrs.)	15-17	16	14
Tocopherols (%)	0.08-0.12	0.095	0.2
Unsaponifiables (%)	0.5-0.7	0.92	0.5-1.6
Deodorized Flavor	Choice	Choice	Beany
GLC Fatty Acid (%)			
Myristic	1.0	0.8	0.1
Palmitic	25.0	25.4	15.5
Palmitoleic	0.7	0.9	-
Stearic	2.8	1.6	3.2
Oleic	17.1	14.5	22.3
Linoleic	52.7	51.6	54.5
Linolenic	-	-	8.3
Arachidic	-	-	0.2
Eicosenoic	-	-	0.9

[a]P. A. Williams, "Characteristics and Value of Glandless Cottonseed Oil," p. 24, presented at the Cottonseed Quality Research Conference, Greenville, August, 1962.

With respect to physical and chemical (quality) characteristics in the unhydrogenated state, cottonseed is preferred over soybean. Cottonseed oil quality is superior to soybean in terms of stability, flavor, and range of uses.

The major quality disadvantage of regular cottonseed oil is the color level as measured on the Lovibond red scale. While there is wide variation by mill, region and season, the lab bleach color of lab-refined regular cottonseed oil typically ranges from 0.9 to 6.5 with an average of 2.8.

Generally, consumers prefer light oil for salads and frying and white shortening. The finished product color limit for such products is usually set in the range of 1.0 to 2.0 Lovibond red. Thus, regular cottonseed oil often requires over-refining or re-refining to meet premium product color limits.

In the unhydrogenated state, soybean oil for edible usage is quite limited because of poor keeping quality and flavor stability. Quality parity with cottonseed oil is obtained by selectively hydrogenating soybean oil to an iodine value (measure of degree of saturation) in the range of 105 to 110 (equivalent to cottonseed oil). Soybean oil has the advantage of being consistently light in color.

Glandless cottonseed oil has been found to be similar in physical and chemical characteristics to regular cottonseed oil with the exception of color (Williams, 1962). From available information, it appears that the lab bleach color of lab-refined glandless cottonseed oil would be in the range of 0.7 to 2.5 Lovibond red. It is probable that glandless oil could meet premium product color limits without the expense of excessive processing. A comparison of oil characteristics is given in Table 1.

STORAGE

Gossypol type pigments and their oxidation products are the major sources of cottonseed oil color (Bailey, 1948). Both laboratory investigation and actual industry experience have demonstrated that the color of crude cottonseed oil is a function of the gossypol concentration, oil temperature and time in storage. The content of gossypol and related pigments in glanded crude oil depends upon the origin and handling of seed and the method of extraction. According to Eckey (1954), the range of gossypol pigment in crude cottonseed oil is given as follows:

OIL EXTRACTION METHOD	GOSSYPOL CONTENT (%)
Hydraulic Pressed	0.02 - 0.11
Screw Pressed	0.25 - 0.47
Hexane Pressed	0.05 - 0.42
Cold Pressed	0.005 - 0.009

Bailey reported significant color rise in crude cottonseed oil heated to 150° F. and held for only 15 minutes (Bailey, 1948). Solvent extracted cottonseed oil has been found to have especially low color stability compared to mechanically expressed oil. The practical limitation on storage time for crude cottonseed oil to avoid significant color intensification is shown as follows:

EXTRACTION METHOD	MAXIMUM TIME SUMMER	MAXIMUM TIME OTHER SEASONS
Solvent Extracted	2 weeks	1 month
Mechanical Expressed	1 month	2 months

Crude soybean oil can normally be stored up to two months without significant deterioration.

No conclusive data is available on the performance of glandless crude cottonseed oil in storage. With essentially no gossypol content, it is highly probable that glandless crude could be stored for at least three months without problem.

It is difficult to place a specific dollar value on allowable storage time. However, in cases where regular cottonseed crude are stored too long, the refining loss and bleaching cost to produce light oil are significant. Longer allowable storage time has economic importance to the oil buyer in being able to purchase greater quantities in a depressed market without concern for degradation in storage.

Properly refined cottonseed oil has excellent stability and can be safely stored for several months.

Being more unsaturated and susceptible to oxidation, refined soybean oil should be stored no longer than two months.

PROCESSING

Refining

The purpose of refining is to remove the undesirable impurities from vegetable oil. In refining cottonseed oil, color removal (reduction) is a major objective. Normally, cottonseed oil refining is controlled on the basis of meeting a specific color target based on the bleached color of the refined oil and set relative to the color grade of the crude. Caustic soda is the predominant refining reagent used. Caustic strength and quantity, caustic-oil mixing time, and temperature must be carefully controlled to avoid excessive reaction with (saponification of) the oil constituents and, thus, to maximize the yield of refined oil. Refining darker crudes necessitates the sacrifice of yield to achieve sufficient color reduction to finally meet the finished product color limit. Often, re-refining (double refining) with weak caustic is preferred to achieve the color reduction with better yield performance over single refining with strong caustic.

Refining yield is one of the most important economic factors to consider in vegetable oil processing. Refined cottonseed yield over the last 10 crop years is estimated to be 92 percent. With the usual consistent quality of crude soybean oil and no particular refining problems, yield for the same period is estimated to be 97 percent. There is not sufficient information available to make a conclusive estimate on refining yield for glandless cottonseed oil. However, based on the information available and the expected consistency for light color, it is assumed that the refined oil yield for glandless would be about 95 percent. Using current market prices, assuming

the glandless price would be equivalent to regular crude, and adjusting for the value of soapstock (byproduct) recovered, the net cost of the oils through refining are given as follows:

1.	Regular Cottonseed Oil	=	\$0.235/Lb.
2.	Glandless Cottonseed Oil	=	\$0.231/Lb.
3.	Soybean Oil	=	\$0.214/Lb.

The net costs given do not include normal refining expenses which would be higher for regular cottonseed oil due to greater caustic soda usage and some proportion of re-refining. Refining cost of regular cottonseed oil over glandless and soybean is estimated to be \$0.002/pound.

Bleaching

Following refining, vegetable oils are bleached to achieve further color reduction by a means more economical than over-refining. An adsorbent, usually natural or activated clay, is added to refined oil for removal of color pigments. After the adsorbent has had sufficient contact time with the oil at an elevated temperature, it is removed by filtration. Bleaching earth usage for regular cottonseed oil typically ranges between 0.3 and 2.4 percent and averages 1.0 percent for the reduction of red color. Soybean oil is normally bleached to a green color (chlorophyll) endpoint, and bleaching earth usage averages about 0.5 percent. Based on experience with light regular cottonseed oil, it is assumed that bleaching earth requirements for glandless would be about 0.5 percent.

The economic implications to be considered for bleaching consist of the adsorbent cost and the loss of oil retained in the bleaching earth. Thus, the cost difference of bleaching regular cottonseed oil compared to both glandless and soybean oil is \$0.001 per pound.

Hydrogenation

The purpose of hydrogenation is the modification of the oil molecule to (1) change from a liquid to a plastic or semisolid state for meeting the desired properties of shortening, margarine, or other products; and (2) improve the stability or keeping quality by reducing the level of linolenic acid (highly unsaturated) components. Hydrogenation is accomplished by reacting oil with hydrogen in the presence of a nickel catalyst. While some color reduction is achieved in hydrogenation, it is a side benefit and not the major consideration.

As previously stated, hydrogenation is an essential step in the utilization of soybean oil. The level of linolenic acid chains in the oil molecules must be reduced to have acceptable properties for most food uses.

Hydrogenation is considered here in the context of the economic implications to achieve soybean oil quality parity with unhydrogenated cottonseed oil. The out-of-pocket expense for hydrogenating soybean oil to a quality parity with cottonseed oil is calculated to be \$0.006 per pound. About 65 percent of the cost is for energy. As the cost of energy increases and natural

gas availability for a hydrogen source diminishes, the hydrogenation cost can be expected to become an even more significant factor in the selection of a particular vegetable oil.

CONCLUSIONS

It can be concluded that the merits of glandless cottonseed oil make it not only superior to regular cottonseed oil but more economically competitive with soybean oil. Considering differentials from crude price through processing expense to achieve quality parity, the present cost comparison of the oils is given as follows:

OIL	COST DIFFERENTIAL ($/POUND)
1. Soybean Oil	Base (minimum cost)
2. Glandless Cottonseed Oil	0.011
3. Regular Cottonseed Oil	0.018

The specific advantages of glandless over glanded cottonseed oil are outlined as follows:

1. Color stability of crude oil should provide for at least three months allowable storage time.
2. A three percent improvement in refining yield should be achieved.
3. Refining cost can be reduced $0.002 per pound by requiring less caustic soda and eliminating the need for re-refining.
4. Bleaching cost can be reduced by $0.001 per pound by requiring less adsorbent and reduction of oil-in-earth loss.
5. The consistent light color of glandless oil makes it applicable to the full range of premium oil products.
6. Applying the $0.006/pound process savings through refining to the total cottonseed oil produced for 1976, the savings potential by 100 percent conversion to glandless would be: ($0.006/pound)(1.2 billion pounds) = $7.2 million per year.

Compared to soybean oil, glandless cottonseed oil has a significant quality advantage and is more cost competitive than regular cottonseed oil. The glandless cost differential with respect to soybean oil can be expected to decrease because of the energy requirements required to hydrogenate soybean oil to a quality parity with cottonseed oil.

The potential benefits of glandless cottonseed oil are sufficient to justify priority attention for further investigation and development. To fully verify the benefits of glandless oil, sufficient production is needed to accomplish the following:

1. Conduct crude oil storage tests to confirm color stability.

2. Make full scale refining runs to demonstrate expected yield performance.

3. Process and utilize the oil on sufficient scale to demonstrate consistent performance.

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DISCUSSION

S. P. CLARK I'm afraid I didn't quite follow through all of your economic figures. Can you summarize them in terms of what the comparative price would be for glandless oil and soybean oil when you take into consideration the differences in refining and all these other things you talked about? In other words, I don't know whether glandless oil is worth the same, more or less, than soybean oil.

N. J. SMALLWOOD Let me just repeat the rationale which I used in dealing with the economics. First of all, I took the current market prices and I dealt with the differential cost in terms of refining yield. Then I made the adjustments for refining yield for the three oils in consideration. Next, I took the differential refining expense which was .2 of a cent per pound and looked at the differential for bleaching. As far as hydrogenation, I took no expense at all for cottonseed oil because it is at a premium quality level. Then I took the amount of the cost of hydrogenating soybean oil to a quality equivalency with cottonseed oil, and merely looked at the differentials above the crude price. Does that answer your question?

S. P. CLARK Well, what do they add up to?

N. J. SMALLWOOD Let us look back at the charts.

S. P. CLARK I just want you to summarize all that in one numerical comparison.

N. J. SMALLWOOD This chart is really the final summary on a quality parody basis after hydrogenation bean oil. Again, bean oil being the lowest cost, the differential over glandless is 1.1 cent per pound over regular cottonseed oil, 1.8 cent per pound. Does that answer your question?

R. J. MIRAVALLE I would like to ask a question for clarification. I realize it takes a tremendous amount of glandless oil in order to make these runs, and I would like to know whether the information that you have been giving us is from actual observation or speculation? Do you have hard data? Or, are you saying that this is what you would expect based upon certain assumptions and that you would like to see research data to verify what you have hypothesized.

N. J. SMALLWOOD The source of the information comes primarily from P. A. Williams' presentation at a conference in Greenwood, Mississippi. I believe in 1962. He was not very specific about yield expectations. The projection or the assumption that the yield would be 95% is based on experience with better quality regular cottonseed oil, which I think is a safe assumption, and would be applied to glandless. So there is a degree of assumption there.

R. J. MIRAVALLE Well, I want to be sure because what it seems you are asking for is more research in this area to make these verifications now that we have sufficient glandless seed or can get sufficient field production of seed in order to make these runs. Is it correct to say that you would like to see a sort of a substitute for research, say, to produce enough oil to make some full-scale refining runs? Is there anyone in the audience that has had some experience with any runs? George, (Cavanagh) have you? Even in the laboratory with field deteriorated seed for example? Has anybody run any laboratory studies? We have had with the glandless development over the years a lot of speculation and sometimes it gets mixed up with actual facts and hypotheses and that is what I wanted to try to get clear. In my opinion research on oil from glandless seed is needed.

W. H. MARTINEZ I was wondering, does glandless offer the potential of producing a new product from the oil in terms of lecithin recovery as you do in soybean oil?

N. J. SMALLWOOD Wilda, on that subject you are out of my area of expertise. I will defer that to someone who does have the expertise.

THE ADVANTAGES OF GLANDLESS COTTONSEED MEAL IN ANIMAL FEEDS

By Harold L. Wilcke

Nutritionists in both the public research institutions and in private industry have attempted for many years to solve the problems involved in finding an economical and practical means of eliminating the undesirable effects of gossypol in cottonseed meals when fed to animals, and particularly the non-ruminants. The feeding of cottonseed meals with excessively high content of free gossypol to non-ruminants has produced results which range from the undesirable to the actually toxic. Thus, in feeding laying hens, cottonseed meals with the higher levels of free-gossypol, one will expect to see discolored egg yolks which are very undesirable. In addition, deleterious effects on the hatchability of those eggs when used for reproductive purposes have been demonstrated. When fed to young animals, toxic effects, and even death, may result.

However, research has demonstrated some safe limits in which the cottonseed meals may be fed. Thus, a safe level of .04% free-gossypol in a cottonseed meal, fed at levels from 10% to 20% depending upon the intended use, have been established as being quite safe. It has been further established that the gossypol may be essentially inactivated by the addition of certain forms of iron to the diet, thus permitting the use of meals with higher levels than those that have been indicated as the safe levels. Traditionally, cottonseed meal has been the protein supplement of choice for many beef cattle breeders and also dairy cattle breeders, and it certainly has been the most economical in many cases as well.

This discussion, today, is concerned not with the overall place of cottonseed meal in the animal ration, but rather with the advantages that might accrue to both the producer and the user of cottonseed meals if the problems concerned with the undesirable fraction, gossypol, might be eliminated. In this respect, the consideration of glandless cottonseed meal for animal feeding is quite different from the consideration of the production of the glandless meal. In feeding, there are no known undesirable effects due to the elimination of the gossypol. Anything that is done in decreasing, or better, eliminating gossypol is all to the good in feeding animals. The question then arises: How good and what is it worth to the animal feeder?

There are two classes of advantages to the feeder in the use of a glandless cottonseed meal. The first is the intangible type, on which it is impossible to put any specific measure or monetary value. In this category we might list the freedom of concern over:

a. Whether mistakes might be made and more than the safe level of the meal carrying gossypol might be added inadvertently to the formula.

b. When iron is used whether, in fact, the proper amount of iron has been incorporated in the formula.

c. For the feed manufacturer in these days of product liability, whether poor results, toxic symptoms, or other untoward effects caused by something other than the cottonseed meal might be attributed to the cottonseed meal itself. The concern over just such accusations has limited the use of cottonseed meals by feed manufacturers. Not only do such factors curtail the use of the cottonseed meals, but they result in a somewhat lower value being placed on the cottonseed meals as protein supplements. The amount of this discount depends upon the philosophy of the particular feed formulator. Those who have confidence in their ability to handle these problems discount the value less, of course.

The second class of advantages we would describe as being the tangible effects of the glandless meals and we will attempt to put some type of evaluation on these. However, before getting into this type of analysis we must have a clear understanding of what we are talking about. First, are we justified in proposing a definition which would establish an absolute zero for the gossypol content of the glandless cottonseed? This, of course, would be Utopia. However, I think we must be realistic and recognize the fact that we will not have cottonseed meals with an absolute zero content of gossypol for any time in the foreseeable future, or, at least not in the early stages of production. At the risk of making a suggestion that might result in acceptance of a minimum rather than a maximum with the ultimate goal of achieving zero, or very nearly so, we must be sufficiently pragmatic in our discussion to accept the fact that the considerations that follow would be applicable to meals which are not completely glandless, but which might contain up to .01% free-gossypol. The results of Heywang et al. (1965) and Heywang and Vavich (1965) would indicate that even at this level there might be a slight problem with discolored yolks if the eggs were to be stored over extended periods of time. Egg storage certainly is not the common practice that it was at one time, but if eggs are to be stored, certain restrictions would have to be placed upon the amounts of these meals even with this low level of gossypol that might be used in laying rations. The alternative, of course, would be to supplement with iron, as is the case at the present time with the low gossypol meals. While the lipid composition does influence the amount of discoloration in eggs, the data on the effects of the lipids from the glandless cottonseed are lacking, in so far as we have been able to determine.

This discussion, obviously, is going to be concerned primarily with the use of cottonseed meals for monogastric animals, and the effects that glandless might have in usage for these animals. This approach is taken because we can see no reason why the difference in gossypol content should affect the use of cottonseed meal in the rations of ruminants, with two exceptions:

1. For the very young animals before they become ruminants, which would mean in prestarters for calves, and

2. In cases of exceptionally high producing dairy cows where excessive amounts of the protein supplement might be fed.

TABLE 1.--Effect of Gossypol on Metabolizable Energy Values of Cottonseed Meal*

Gossypol Added to Glandless	Source	M.E. Kcal/Gm.	M.E. Kcal/Lb.
0	-	3.26	1478
.023	Pigment Glands	3.26	1478
.046	Pigment Glands	3.20	1451
.092	Pigment Glands	3.11	1411
.050	Pure	3.20	1451

*Hill and Totsuka (1964)

TABLE 2.--Effect of Fiber on Metabolizable Energy Values of Cottonseed Meals*

Meal	Protein	Fat	Fiber	M.E. Kcal/lb.
Glandless Solvent	53.6	2.6	3.4	1261
	49.9	2.1	6.1	1155
	42.7	2.1	11.2	1006
Glanded Prepress Solvent	52.1	2.7	4.1	1067
	50.8	1.3	6.3	906
	42.0	1.0	10.7	881
	24.8	.8	20.6	402

*Watts

We are, then, classifying the very young calf as a monogastric animal and consider the effects to be similar to those on other monogastric animals.

There are several characteristics of cottonseed meal which affect the amount and frequency with which they may be used in monogastric animal rations. In addition to gossypol, the amount of metabolizable energy in the product may be limiting, the amount and percentage of available lysine may be a limiting factor in comparison with the other available plant protein supplements, which in most cases is soybean meal.

In Table 1 we have summarized some work by Hill and Totsuka (1964) indicating the effect of gossypol on the metabolizable energy of cottonseed meal products.

Notice that these are all exceptionally high values for energy but that there is a decrease with increasing amounts of gossypol which has been added to a glandless cottonseed meal. Therefore, we would expect that the glandless cottonseed meals would be somewhat higher in available metabolizable energy than meals produced from the glanded varieties. It is significant to note that the energy values obtained were the same from the addition of pigment glands and the pure gossypol, indicating that this is, indeed, a gossypol effect.

In Table 2 we have summarized some of the effects of fiber on metabolizable energy values in data supplied by Watts (1977) of the Louisiana station.

Obviously the protein content of these meals decreases as the amount of fiber increases, but it is quite fortunate that the range of fat values for these particular meals was very small. Therefore, the differences that are shown in metabolizable energy ranging from 1,261 down to 1,006 may be attributed primarily to the fiber content of these particular glandless meals. The same type of data are presented for the glanded meals with the same trend but here, an even higher level of fiber was used and the results are even more dramatic, dropping to 402. While the removal of fiber from the cottonseed meals does remain a problem, these data demonstrate the fact that if means can be found to lower the fiber content of cottonseed meals, they will be used more extensively in rations of poultry, and this would also apply more emphatically to swine. Hill's (1963) data indicate that from 20 to 30% of the difference in metabolizable energy between the cottonseed meals of different fiber content cannot be explained by the difference in fiber but appears to be due to lower utilization of protein or carbohydrate components in the cottonseed meals. In his experiments the metabolizable energy of the soybean meal control diet indicated an M. E. value of about 1,260 Kilocalories per pound for the soybean meal, which is the value shown in Watts' (1977) data for glandless cottonseed meal.

The amino acid lysine is also one of the more important limiting factors in the use of cottonseed meal in animal rations. Because of the fact that gossypol and lysine do react, reducing the availability of the lysine, the glandless cottonseed meals should have a higher content of available lysine. Data presented by Harper (1967) on glandless and glanded meals produced in the same plant show a decided difference in the lysine content of the glanded and glandless meals (fig. 1).

The extension of the curve shows that under careful laboratory processing conditions this content of available lysine may be increased even

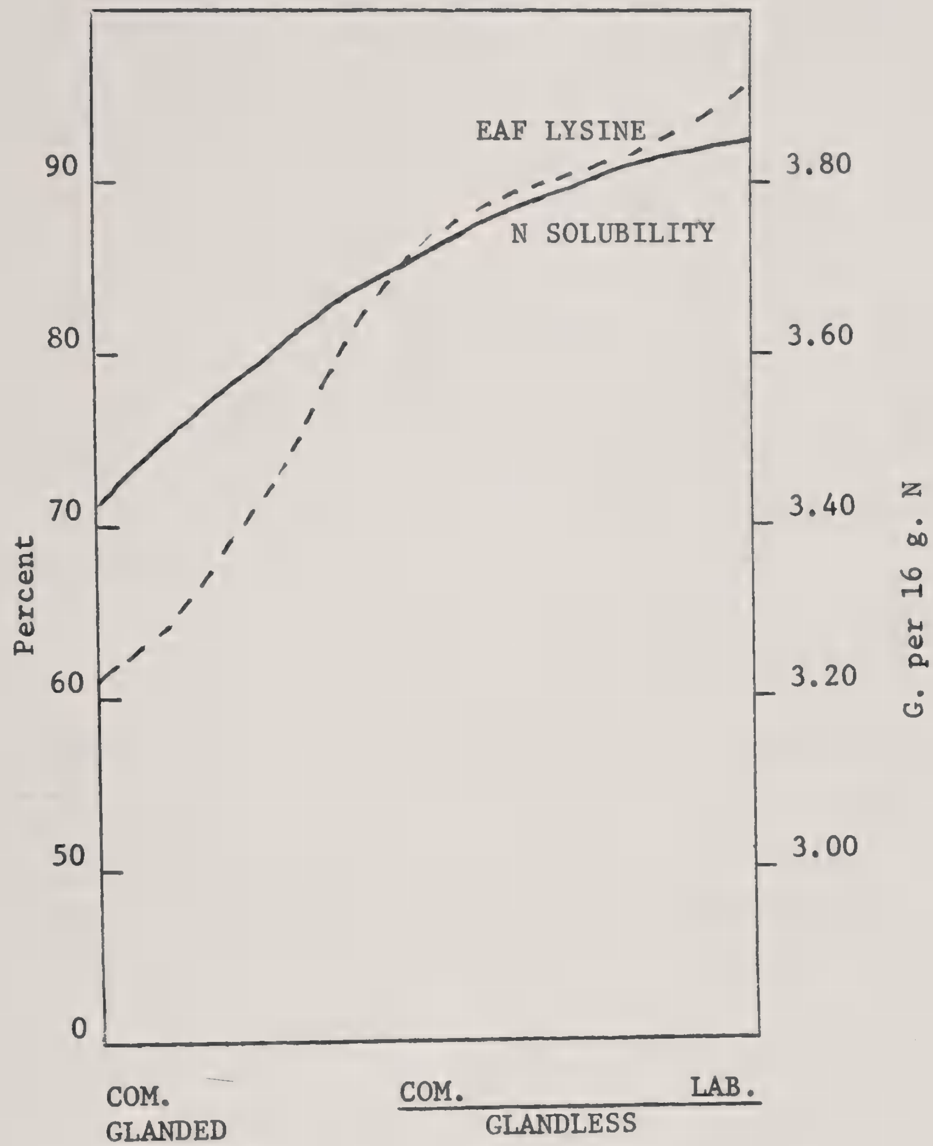

Figure 1.--Nitrogen solubility and available lysine of glanded and glandless cottonseed meals. From Harper (1967).

TABLE 3.--Relationship Between Epsilon-Free Amino Lysine and Chick Gain*

Commercial CS meal	E-NH_2 lysine, g/16 g N	Weight gain, g
112	3.54	249
109	3.37	255
111	3.13	224
107	2.97	206
110	2.85	181
108	2.50	166
113 (108 + extra heat)	1.58	116

*Adapted from Phelps (1962).

TABLE 4.--Response of Swine to Commercial Cottonseed Meals*

Cottonseed meal	% free gossypol	E-free amino lysine g/16 g N	Av. daily gain, lb.	Lb. feed/ lb. gain
9	.05	3.2	1.30	4.10
12	.02	3.7	1.23	4.43
10	.04	3.0	.87	4.61
11	.07	3.5	.86	5.27
8	.06	2.2	.67	5.99
13**	.03	1.6	.37	7.38

The data indicate that despite vastly different gossypol levels, epsilon-amino free lysine was reasonably correlated with weight gains.

*Adapted from Phelps (1962)
**Meal 8 plus additional heat

further. Perhaps this should be stated the other way, in that there is less binding of the lysine under carefully controlled laboratory conditions, indicating the possibility for improved processing. It should be pointed out that lysine can react with any compound with free aldehyde, and those reactions are accelerated by higher temperatures used to inactivate gossypol. This graph also indicates the effect of the processing on the nitrogen solubility of the proteins, which is another one of the factors in determining the biological value of the protein supplement.

While this increase in the available nitrogen value for the glandless meals will improve its value and acceptability, it may not necessarily correct the lysine deficiency in all types of rations. Some additional lysine supplementation is frequently necessary. Phelps (1962) has summarized data for the relationship between epsilon-free amino lysine for growth of chicks and also for swine. These data are presented in Tables 3 and 4.

Thus, we may expect an improved performance of the glandless over the glanded meals in both swine and poultry rations. However, in order to test this hypothesis, these meals must be evaluated in actual formulas to determine their value in supplementing other ingredients to meet the nutrient requirements of some of the more common species of animals. Ideally, this should be followed by feeding experiments, but the formulas will provide a good estimate of the order of magnitude of differences between the two types of products.

Because of the fact that there has been very little, if any, commercial production of glandless cottonseed meal to be used in animal feeding, it follows that there are no complete analytical values on representative meals. We have, therefore, combined some results provided us by Dr. A. B. Watts (1977) of Louisiana State University with other values from Garlon Harper (1977) of the NCPA to structure analyses that should be attainable in good commercial manufacture (table 5).

It should be noted that in these analyses as represented here, the epsilon-amino lysine is somewhat higher in the glandless than in the glanded meal. The lysine analyses were run on meals produced in the same plant by the same process and therefore should be fairly representative of what one might expect. It should also be noted that the glandless meal is not gossypol-free. However, it does qualify under the definition as we have stated it earlier.

These analyses were used in computer runs to determine the relative value of the glandless and the glanded prepress solvent meals in several types of rations.

As expected, when these meals were put into a formula for a high energy dairy ration, there was no difference in their value. However, these results did indicate that cottonseed meals with analyses as represented here could compete with either a 44% or a 47-1/2% soybean meal on a cost basis.

When these meals were used in a 15% protein ration for laying hens, the glandless meal proved to be worth approximately $9 per ton more than the prepress solvent glanded meal. Since lysine is not quite so critical in the ration for the laying hen, the difference in value here would appear to be primarily due to the difference in energy values for the two types of meal.

When these cottonseed meals were introduced into a 16% protein formula for growing swine, there was a considerably greater difference in the indi-

TABLE 5.--Analyses of Cottonseed Meals Used in Evaluation

		Protein	Fat	Fiber	EAL Gm/100 gm N	Free Gossypol	Total Gossypol	ME
I.	Glandless Cottonseed Meal (Solvent)	50.5	2.5	5.5	3.72	0.009	0.04	1200
II.	Glanded Prepress Solv.	50.5	2.5	6.3	3.18*	0.27*	0.96*	1040

*Values from solvent process meals, but from same plant as the values for glandless.

cated values. In this case, the glandless meal was worth $22 more per ton than the glanded. However, the absolute value for both meals was less, and the spread between soybean meals and both of these cottonseed meals was greater than in the laying hen formulas. There are at least two explanations for this variation in values. The first is that lysine is more cost limiting in the swine ration because of a higher requirement for that amino acid, and the higher lysine content of soy protein does produce an advantage. Secondly, this would be a higher energy type ration than the one for the laying hen.

The metabolizable energy values available for swine indicate a greater increase over those for the chicken for the soybean meals than for the cottonseed meals. These differences may be resolved somewhat as more data become available. In the case of the swine ration, the cottonseed meals would not compete successfully on an equal cost basis with either the 44% or 47-1/2% protein soybean meals.

The differences we are interested in, in this discussion, are primarily the differences between a glandless and a glanded cottonseed meal. The absolute differences between the two meals would, of course, depend upon prices not only of the meals but of some of the other ingredients that are used in the different types of formulation. The differences that have been quoted here were based upon an assumed price of $183 per ton for the cottonseed meals, putting both of them on an equal price basis. Obviously, the price that can be realized for either of the cottonseed meals will depend upon its competitive relationship with other sources of protein such as soybean meal, and the use of non-protein nitrogen sources in rations, particularly those for the ruminant.

Pet foods are becoming increasingly important in the total picture of prepared animal feeds. However, it may be surprising that a survey of the leading brands of commercially available pet foods that are on the market at the present time failed to show the use of cottonseed meals in this type of food product. Therefore, any use that can be achieved by the production of glandless cottonseed meal would be a plus factor. There is interest

among the pet food manufacturers in evaluating a glandless type of cottonseed meal in the pet food areas. This, at present, seems to be a total market of 4-1/2 to 5 million tons of total pet foods (Pet Food Institute, 1975). We can see no particular reason why glandless cottonseed meal should not be used in some of these products and, in fact, it might be demonstrated to have some characteristics that would be advantageous. No computer runs have been made for the pet foods because no data are available on the relative values for the pet animals.

While cottonseed meal was used in some of the fish foods which were commercially available at one time, there does not seem to be any usage at the present time. This, however, is not related to the gossypol content of the meals and we would not expect to see any advantage for glandless meals in the area of fish foods.

We are not aware of any use of cottonseed meals in calf milk replacers. There appear to be two reasons for this - high fiber and gossypol. Interest has been expressed in evaluating glandless cottonseed meals for this purpose, providing that a flour can be produced which would analyze approximately 70% protein, less than 5% fiber, and less than .01% gossypol (preferably 0 gossypol). There is presently a market of 150,000 to 160,000 tons of calf milk replacers sold in the U.S., and if cottonseed meal or flour could find a place in these formulas at even a 5% level, the usage could be 7,500 tons, with possibilities of greater usage.

It is obvious, therefore, that with the differences in values indicated by the above calculations, more of the glandless cottonseed meal would enter into the computer formulations for poultry and swine and possibly in pet foods and milk replacers, and that we would expect no difference in the use for the ruminant except in those cases where additional bins were not available for storage, limiting the use by the feed manufacturer to only one type of cottonseed meal. This would be true only for those feed manufacturers producing feeds for both ruminants and monogastirc animals. Thus, the advantages of producing a glandless cottonseed meal, as far as the feed manufacturing industry is concerned would be:

1. Cottonseed meal would be used in a much broader list of rations because of the freedom from the restriction of the use imposed by the presence of gossypol.

2. The feed industry would price the glandless cottonseed meal into their rations at a higher price than is the case with the glanded cottonseed meals.

3. Specific value differences are valid only for meals with specific analyses used in specific formulas, but these values do provide good estimates of the differences in the value of glandless and glanded cottonseed meals for the feeding purposes discussed.

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POTENTIAL FOR EDIBLE PROTEIN PRODUCTS FROM GLANDLESS COTTONSEED

By E. W. Lusas, J. T. Lawhon, S. P. Clark, S. W. Matlock, W. W. Meinke, D. W. Mulsow, K. C. Rhee and P. J. Wan

More research has been done on processing and utilization of glandless cottonseed than could possibly be reviewed in a single paper. Texas A&M University, The Southern Regional Research Center in New Orleans, Texas Technological University, Texas Women's University, and other organizations and companies have been highly productive. Texas A&M University's program started in the fall of 1961 with receipt of 5200 pounds of Acala variety glandless cottonseed from the U.S. Cotton Field Station, Shafter, California.

GENERAL PROCESSING

Processes have been developed for producing edible kernels, defatted flour, and protein concentrates and isolates from glandless cottonseed. A flowchart for producing edible kernels and defatted flour is presented in Figure 1. When considering glandless cottonseed, one must realistically accept the fact that trace amounts of glanded seed will always be present, at least until glandless cottonseed is grown widely. It was demonstrated that protein ingredients made from hand picked seeds are free of gossypol. Off-color problems do not occur in defatted flour until the content of glanded seed exceeds 2 to 3 percent in the shipment. Assuming that the average level of gossypol in glanded seeds is about 1.2 percent, the resulting flour would have a gossypol content of about 300 ppm (Wan *et al.*, 1977). This is within the 450 ppm level permitted by the FDA (Fed. Reg., 1974). When we say "glandless cottonseed", we really mean "low gland content" seed. However, we can be assured that highly acceptable human food products can be made, provided the level of glanded seed is kept low enough.

At the Food Protein Research and Development Center, seed is cleaned by a Bauer Seed Cleaner, a piece of equipment commonly used in the oilseed processing industry. Yields of cleaned seed depend upon the variety and quality of seed, and previous ginning operations. A live steam conditioning treatment, which reduced breakage and maximizes yields of large kernels, was developed by Lawhon (1970). Conditioning also increases yield of kernels if seed is low in moisture content (Clark *et al.*, 1974). In order to enhance separation after dehulling, seed is not delintered. Optimum linters content is about 8 to 10 percent. Equipment capacity is decreased and loss of kernels increases if linters content exceeds 10 percent (Clark *et al.*, 1974; Clark, 1977).

Seed is dehulled with a Carver bar huller. The gap between the knives is increased to induce impact hulling, rather than the normal slicing action. After dehulling, the kernels and hulls are separated on a Carver shaker table using aspiration. Several additional pieces of secondary separation equipment are used to recover usable seed fractions, and to yield the final four product

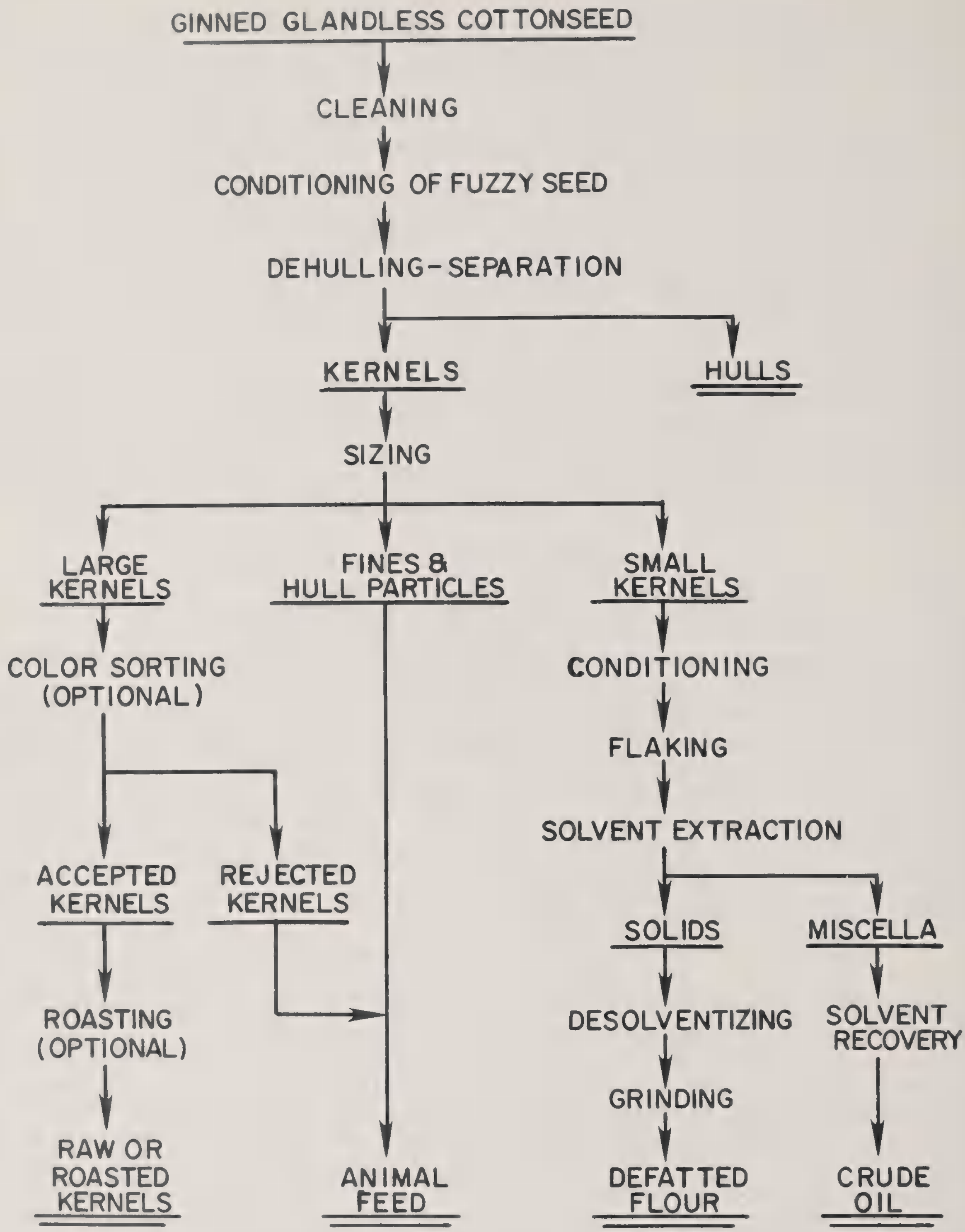

Figure 1.--Flow chart for production of glandless cottonseed kernels and flour.

streams, i.e.: large kernels, small kernels, fines and hull particles, and fuzzy hulls.

Kernels can be prepared for direct consumption or for use in foods as nut replacements. Depending upon purity of seed processed, removal of trace amounts of glanded seed using mechanical sorters may be necessary, although this step increases production costs. Kernels and meats fines can be flaked and extracted with hexane to produce defatted glandless cottonseed flour (Lawhon, 1969; Vix and Decossas, 1969; Brueske, 1970; Smith, 1971; Spadaro and Gardner, 1971). In order to increase oil removal, kernels are conditioned to a moisture content of 8 to 10 percent, and heated to temperatures between 160°F and 180°F before rolling into flakes 0.008 to 0.012 in. thick. Flakes are low in fiber and break easily. They should be handled gently in order to retain good percolation of solvent in the extractor. Production of a meal with less than one percent residual oil content is difficult to achieve unless extractor retention time is increased significantly. Processing by solvent extraction yields high quality cottonseed oil and defatted meal. Meal can be used as such in several food applications, ground into flour, or used in production of protein concentrate and isolate. Composition of glandless cottonseed kernels, flour and protein derivatives is summarized in Table 1.

FOOD USES OF KERNELS

Direct uses of nondefatted kernels are a potential major market for glandless cottonseed. Development of a high protein content nut-like product from whole kernels was one of the first achievements of utilization work at the Food Protein Research and Development Center (Lawhon et al., 1970 a,b). The term "TAMUNUT" (mnemonic for Texas A&M University) was coined as its name in 1968.

Roasted kernels are highly acceptable as a snack item. They have been tested in applications such as noncooked candies, and as toppings on bakery goods and ice cream specialties. A highly acceptable TAMUNUT butter has been made by grinding roasted nuts in equipment used for making peanut butter (Lawhon, 1972). Also, TAMUNUTS mixed with rice proved to be quite tasty. In addition, the protein content of rice (the world's most widely used food) was more than tripled when the roasted kernels were added to dry rice in a 1:1 ratio by volume (Lawhon et al., 1970a).

Nonroasted, or partially roasted, kernels have been evaluated in baked cookies, breads, and a number of cooked candies including the "peanut-brittle" type. Protein fortification of corn tortillas with glandless cottonseed kernels is a successful application of special interest to Southwestern United States and Mexico (Green et al, 1977). Use of cooked kernels as a seasoned meal-course vegetable, resembling popular black-eyed pea dishes, has been well received in informal trials.

Kernels can be used whole or cracked according to the desired texture of the product. Results, often confirmed by taste panel evaluation, have been very satisfactory since glandless cottonseed is typically bland, and more preferred than some other alternatives such as "soy nuts". Because of their pleasant flavor, raw and roasted glandless cottonseed kernels are expected to have considerable potential as food ingredients in the future.

PREPARATION AND FOOD USES OF DEFATTED FLOUR

The greatest potential food uses of glandless cottonseed protein are in

TABLE 1.--Percent composition of glandless cottonseed kernels, flour and flour derivatives

Analysis	Raw kernels[a]	Roasted kernels	Flour[a]	Conc[b]	Isolates SP[c]	Isolates NSP[d]
Moisture	7.0	1.5	4.8	6.1	7.2	6.0
Protein (N x 6.25)	36.2	38.1	59.6	69.0	88.2	70.7
Fat	36.9	40.0	0.8	1.4	0.2	0.2
Fiber	1.6	1.6	2.7	2.8	1.1	1.2
Ash	----	4.2	7.4	11.1	5.8	10.1
Total carbohydrates	6.3	6.7	13.9	----	----	----
Sugars:						
Sucrose	----	----	1.6	----	----	----
Raffinose	----	----	11.3	----	----	----
Stachyose	----	----	0.9	----	----	----

[a] Data from a paper by Lawhon et al., 1977a.
[b] Conc = protein concentrate.
[c] SP = storage protein isolate.
[d] NSP = non-storage protein isolate.

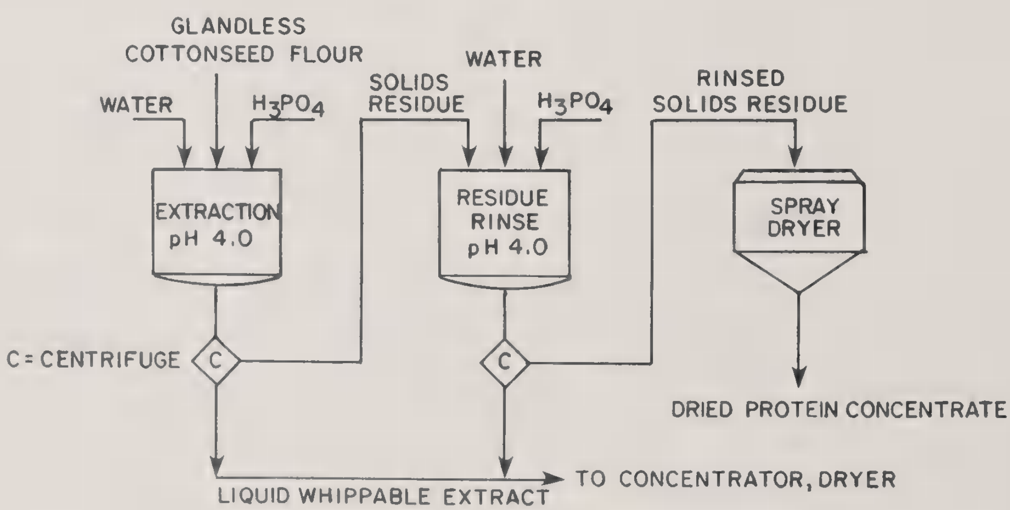

Figure 2.--Simplified flow chart of protein concentrate by a wet-extraction process.

the forms of defatted flour and its derivatives. Use of glandless cottonseed flour has been evaluated in several food products. With proper formulation, it has performed satisfactorily as a protein supplement in bread (Matthews, 1968; Matthews et al., 1970; Rooney et al., 1972; Harden and Yang, 1973); tortillas (Green et al., 1976); cookies (Harden, 1971); cake doughnuts (Lawhon et al., 1975); and in frankfurters (Smith et al., 1973). A whippable extract has also been produced from glandless cottonseed flour, and shows potential in applications where heat-setting is not required (Lawhon et al., 1972a). Glandless cottonseed flour is preferred over soybean flour in some food uses because of its blandness. Glandless cottonseed flour can be texturized by extrusion and used to replace texturized soybean flour in many applications (Spadaro et al., 1971; Marshall, 1973; Eggen, 1974; Molonon et al., 1976). Slight modifications might have to be made in design of the extruder screw and discharge end as compared to a soy-texturizing extruder (Taranto et al., 1975). Texturized glandless cottonseed flour (TCP) has been evaluated as a substitute for texturized soy protein (TSP) in meat patties, meat loaf, frankfurters, and chilies. TCP was found as acceptable as TSP. However, in many seasoned food applications, the blandness of TCP was not an advantage over TSP.

PREPARATION AND FOOD USES OF CONCENTRATES AND ISOLATES

Food ingredients, with increased levels of protein, can be made by processing defatted glandless cottonseed flour into concentrates (70 to 90 percent protein) and isolates (90 + percent protein). Advantages of these ingredients include: unique functional properties, reduction of flatulence sugars, and reduction of water-soluble natural plant pigments.

Concentrates have been prepared from flour by a dry air classification method by Martinez et al. (1967); and by a wet-extraction process (see Figure 2) by Lawhon et al. (1972b). Glandless cottonseed flour is extracted with phosphoric acid at pH 4.0. The liquid fraction which contains natural sugars and soluble proteins is separated for other uses, and the solids are again washed with a phosphoric acid rinse and are then spray-dried to produce the glandless cottonseed protein concentrate. Protein concentrates are less expensive than isolates, but are equally as suitable for certain applications. Use of protein concentrate, prepared by wet extraction procedures, has been successfully demonstrated in meat loaf. Test loaves in which 25 percent of the meat was replaced by partially hydrated concentrate (water to concentrate ratio 1.9:1.0 by weight), had 55 percent less cookout loss than all-meat control loaves. Yet, protein content of meat loaves containing concentrate was not reduced from that of control loaves (Lawhon et al., 1972b). Also, glandless cottonseed concentrates have been used as protein supplements in formulating acceptable high-protein breads (Kahn et al., 1976).

Several important processes for making protein isolates have been developed at the Southern Regional Research Center at New Orleans (Berardi et al., 1969; Martinez et al., 1971; Berardi et al., 1972). The Two-step Extraction Procedure (shown in Figure 3) and the Selective Precipitation Procedure, each yields two distinct isolates by dividing glandless cottonseed protein into nonstorage protein (NSP) and storage protein (SP). (Usually storage protein is considered as originating from discrete bodies deposited within the seed, and the nonstorage protein as being the "cement" which holds the different structures in the seed together.)

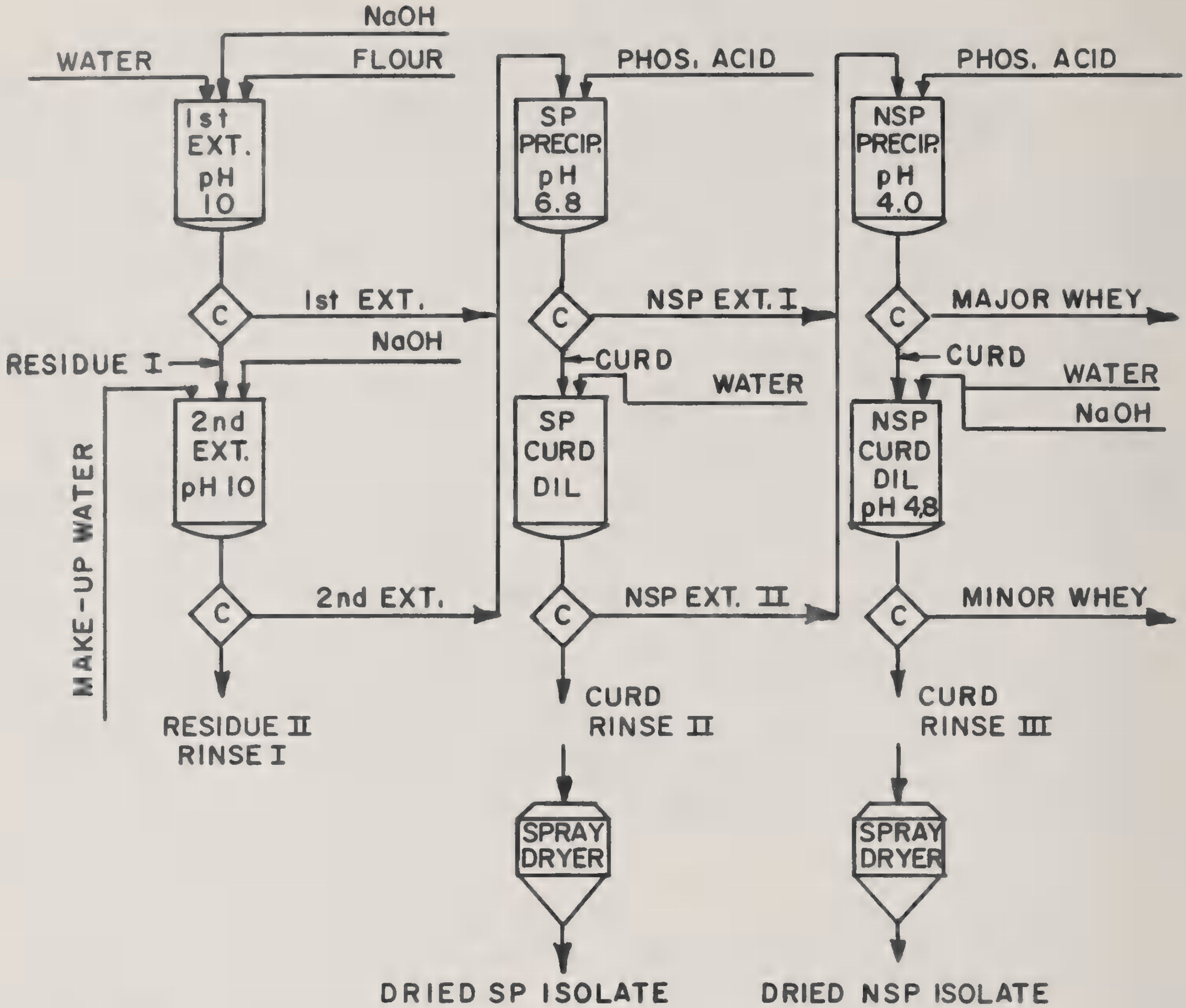

Figure 3.--Flow chart of two-step protein isolation process.

NSP and SP isolate fractions have different functional and nutritional properties which offer considerable latitude in the applications that can be made of them. NSP isolates possess better whipping properties than SP isolates; while SP isolates have superior heat gelation properties (Lawhon and Cater, 1971). NSP isolates contain low-molecular weight proteins, are readily water-soluble, and have minimum solubility at pH 4. SP isolates contain high molecular weight proteins and have minimum water-solubility at pH 7 (Martinez et al., 1970a,b). SP isolates have proven highly satisfactory in bread fortification. At 10 percent replacement of wheat flour, protein content of the loaf is essentially doubled without materially affecting structure of the loaf (Martinez et al., 1969). SP isolates are highly soluble at low (acidic) pH, which makes them suitable for use in protein fortification of beverages (Martinez et al., 1970a).

OTHER DEVELOPMENTS

Several other processing developments in the offing need to be mentioned. The Food Protein Research and Development Center has been working on an aqueous processing method for producing glandless cottonseed concentrates and isolates. This process shown in Figure 4 uses finely ground full-fat kernels as starting material. Cottonseed is ground dry and mixed with water and NaOH at pH 10 to solublize protein and sugars. The non-dissolved solids consisting mainly of fibrous materials are rinsed and dried. The protein is separated by a continuous centrifuge into oil-emulsion, liquid extract and sludge fractions. The liquid extract fraction is acidified to pH 4.5 to precipitate the proteins which are subsequently washed and dried. The whey fraction, containing sugars and some soluble proteins, can be concentrated and dried or processed further.

Various process parameters have been optimized in the laboratory and preliminary pilot plant-scale trials have been made (Rhee et al., 1976). Results indicate that aqueous extraction processing of glandless cottonseed is technologically feasible and produced high quality oil and protein products. It is expected that an aqueous extraction method may successfully remove nongossypol pigments from cottonseed while simultaneously producing high quality oil and protein derivatives. Potential advantages of aqueous processing over solvent extraction of flakes, followed by water extraction of meal, include: 1) lower capital investment; 2) safer operation; 3) production of a broader variety of products; and 4) opportunity to use certain chemicals to remove or inactivate undesirable substances including aflatoxins (Cater et al., 1974). Preliminary utilization trials of aqueous processed glandless cottonseed derivatives have not been made thus far.

Commercial production of glandless protein derivatives probably means building new processing plants. Unfortunately, new industries often have the additional burden of meeting requirements which are not currently imposed on existing plants - for example, environmental pollution restrictions. Conventional methods of producing conttonseed protein isolate yield whey-like liquid by-products. Cottonseed wheys not only pose serious disposal problems, but also constitute substantial economic losses since they contain 20 to 30 percent of the original flour nitrogen, as well as carbohydrates and other nutrients (Lin et al., 1974). Semi-permeable ultrafiltration (UF) and reverse osmosis (RO) membrane systems have proven successful in processing these wheys (Lawhon et al., 1977c).

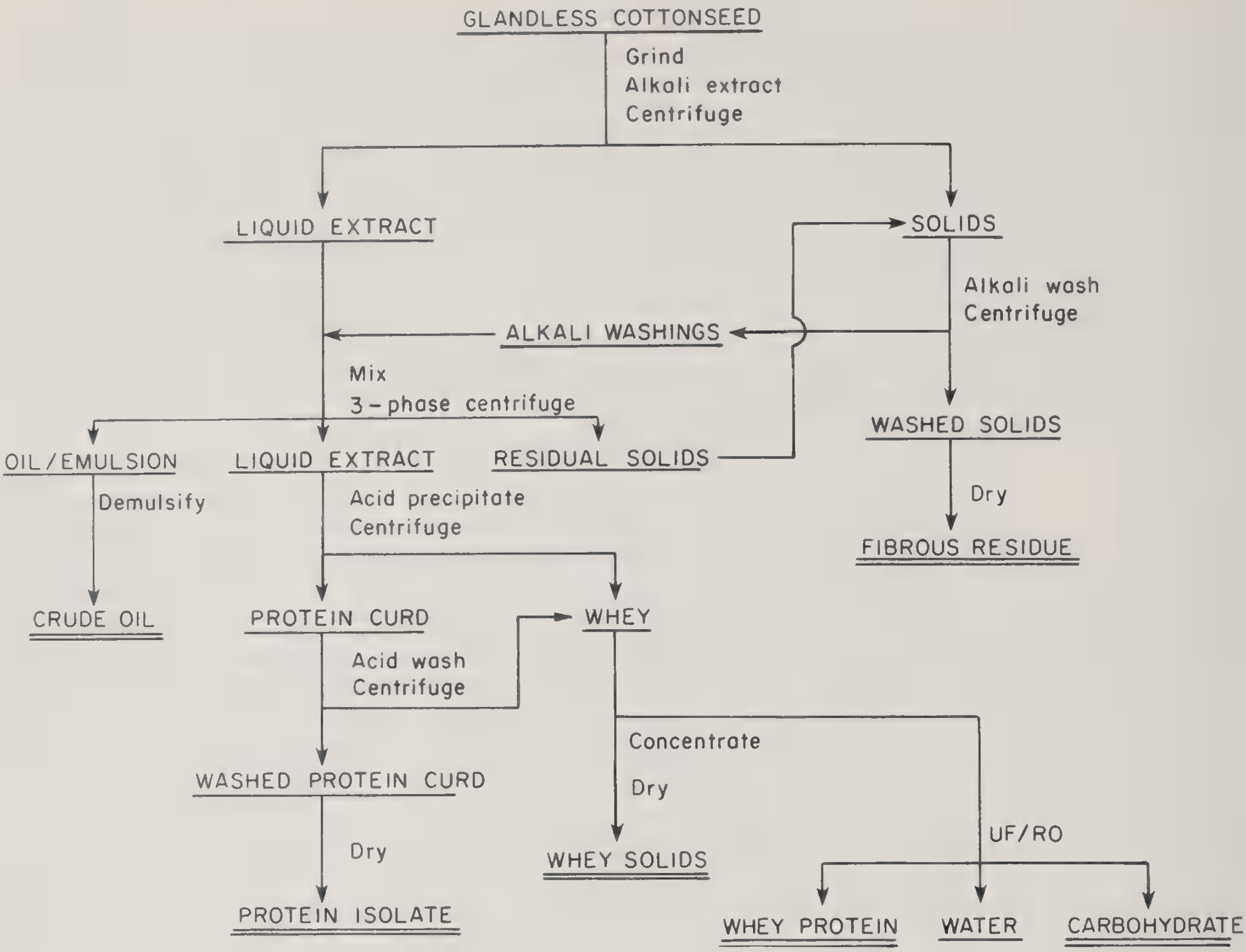

Figure 4.--Flow chart for producing glandless cottonseed protein isolates by aqueous process.

TABLE 2.--Estimated required selling prices for defatted glandless cottonseed flour[a]

Return on investment[b]	Plant capacity (Tons per day)[c] 100	200	400
%	$/lb.	$/lb.	$/lb.
0	0.18	0.16	0.14
10	0.25	0.20	0.18
20	0.32	0.26	0.23
25	0.36	0.28	0.25

[a] Dockside prices; selling costs not included; cottonseed valued at $150 per ton.
[b] After income taxes paid at 50% rate.
[c] Capital investments were $5,014,000, $7,814,000 and $11,417,000.

The Food Protein Research and Development Center is currently evaluating use of industrial UF and RO membrane systems for producing protein derivatives directly from defatted flours. By these techniques, not only is generation of by-product wheys avoided, but the effluent water is recycled for reuse in subsequent processing (Lawhon *et al.*, 1977d; Hensley *et al.*, 1977). In this process whey proteins are recovered along with protein fractions which are concurrently precipitated as isolates. Increased yields are realized, and preliminary studies show that product quality is enhanced (Lawhon *et al.*, 1977b). The economic feasibility of membrane processing is currently being determined.

During the past year, a projected return on investment analysis for building and operating extracted glandless cottonseed flour plants of several sizes was also completed. Results are summarized in Table 2.

The main advantages of glandless cottonseed flour and protein derivatives, in our relatively well-fed country, is their pleasant bland flavor, and their unique functional properties in compounded foods. Acceptability of these materials as extenders in dairy products, for formulating imitation cheeses, and as protein sources in calf starter milk replacers is being evaluated currently. With regard to nutrition the protein in glandless cottonseed flour, when properly processed, has protein efficiency ratios (PER) very near that of casein. Although storage protein isolates are low in protein quality, non-storage protein isolates have shown protein efficiency ratio values which exceed that of casein (Martinez and Hopkins, 1975).

In summary, glandless cottonseed products, including kernels, flour, concentrates and isolates are exciting food ingredients. They are highly acceptable flavorwise, have unique and desirable functional properties for use in compounded foods, and are highly nutritious. Enough research has been completed to show that they offer considerable potential to food processors. Let's get on with their production and commercial use!

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CONSIDERATIONS IN DEVELOPMENT OF GLANDLESS COTTONSEED PRODUCTS: GENERAL PROCESSING REQUIREMENTS

By Wilda H. Martinez

Our General Chairman and previous speakers have given us some very positive reasons for providing glandless cottonseed in the marketplace--the elimination of a potentially harmful substance, gossypol--significant savings in processing energy and in refining costs--new markets and added value for feed products and--a very exciting potential in terms of food products.

I would like now to consider certain aspects of the entire production-marketing system for cottonseed that can be important in the development of glandless cottonseed and its products. First, there is the question of volume of seed. The acreage planted to glandless cottonseed must be large enough to insure that the supply of seed meets the annual demand. Adequate supply is particularly important for the edible protein market and the pet food market. In both these markets, product formulation is dependent upon ingredient characteristics. For optimum development of these markets ample supplies of glandless cottonseed must be consistently available.

Mr. Kromer pointed out that supplies of cottonseed are essentially inelastic because they are tied to the production of cotton fiber. I would like to challenge the breeder and the producer to consider alternatives that might modify this inelasticity. Increases in seed size and seed quantity, with no reduction in fiber yield per acre, should be an acceptable goal. It must be recognized that the major costs in the ginning process no longer reside in the separation operation. The major costs are in the fiber cleaning operations necessitated by mechanical harvesting. What would cover the cost of cleaning if there were no seed? The contribution of seed to the return on fiber, therefore, is real and an increase in the quantity of seed could increase that return.

The quality of cottonseed is also critical, particularly for use in certain feeds and foods. Contamination by glanded seed at any point in the system is a major problem and will be addressed indepth later in the Conference. However, since the philosophy for grading systems increasingly is directed toward emphasis on end use characteristics, and since trading on grade for cottonseed is on the rise, any trading rules developed for glandless cottonseed must incorporate gossypol content as a quality factor. I make this proposal with full recognition that no currently available methodology would be adequate for implementation of such a regulation. Lack of a method, however, does not obviate the need for the regulation.

Two of the quality factors now used in the trading rules are protein and oil contents. The breeder, however, should not direct his attention to either at the expense of the other, but rather should select for both protein and oil contents at the expense of hull and carbohydrate. High oil content is important both in terms of the value of the oil and the resultant facility with which high protein products can be produced from defatted materials. Seed quality and uniformity of composition could also be enhanced through the development of

increased determinance and early but full maturity in the cotton plant.

When an adequate quantity of high quality glandless seed has been produced, it must then be protected from weathering in the field, during rick and module storage, handling in the ginyard, and storage at the oil mill. With glandless, the concern centers primarily on protection from enzymatic and microbiological deterioration which could result in an increased free fatty acid content and/or the presence of mycotoxins. Increased free fatty acids cannot only reduce oil yields but may also cause flavor problems in protein products. With glanded seed, the development of oil color is a major additional concern. The absence of oil color problems could be the single most important and economically beneficial contribution of glandless seed to the cottonseed crushing industry and, most specifically, to the screwpress type of crushing operation.

The solvent extraction operation is essentially the only operation that can take full advantage of the potential of glandless cottonseed. Yet in many respects, managers of even this type of operation must look at glandless seed as a wholly new commodity with new markets and, therefore, new processing requirements. Conditions for flaking, conditioning, defatting and desolventizing that provide for the total process the most energy and cost conserving operation have yet to be defined with a continuous system.

Other changes will be determined by market objectives for the products. If the objective is limited to current markets, then essentially no changes in the peripheral operations would be required and the screwpress operation might even compete successfully. If, however, the objective is to take full advantage of the potential of cottonseed protein as food or feed, certain changes must be made. Active participation in the feed markets for laying hens, swine and feeder calves would require the production of new products containing 50 and 70 percent protein. In the preparation of 70 percent protein products, defatted cottonseed offers a unique advantage in that it can be dry milled and air classified.

Production of high protein products for food or feed, however, would require improvements in dehulling, flake stability, desolventization operations, and sanitation, particularly in the handling of the defatted product. Effective quality control also would be required. If the market objective is specifically edible protein products, then vapor phase desolventization or its equivalent would be essential to protect the inherent nutritive, functional and sensory characteristics of the proteins in the seed.

Ultimately, the cottonseed crushing industry must face the problem and make a decision whether to change or to stagnate. The industry can either take a giant step forward and claim the advantage of a unique, high quality commodity in the form of glandless cottonseed with a potential for new and expanding markets, or it can remain with the glanded variety and accept the consequences of future questions about the safety and acceptability of gossypol-containing products.

It is possible that glandless cottonseed will enter the marketplace only via a specialty dehulling operation, one that provides dehulled kernels to a multi-oilseed crushing operation with the necessary food quality control. However, once such an operation is established and glandless cottonseed expands in both production and marketing, it is also possible that the traditional cottonseed crushing industry may find that the delintering and dehulling operations are its only remaining roles.

REGULATORY CONSIDERATIONS IN DEVELOPMENT OF GLANDLESS COTTONSEED PRODUCTS

By H. Leroy Schilt

This session of the conference has been concerned with two areas of use of glandless cottonseed products. One as a use for human food; the other for animal feed. Either could be the subject of a rather lengthy regulatory debate. I will, therefore, confine my remarks to the application of the Federal Food and Drug regulations and will try to give you highlights, and only highlights, as they apply to both human food and animal feed applications. I will further restrict my remarks to the Generally Recognized as Safe (GRAS) status and the food additive regulations.

The Food, Drug and Cosmetic Act defines food as "food for man and other animals" so that cottonseed products intended for use for humans and those products intended for use for animal feed are covered by the same act. Not only are they covered by the same act, but the regulations are almost identical. The only differences between regulation of animal and human food use of cottonseed products might be in some of the fine tuning of the interpretations and its prior use for animals.

FDA says that a product may be classified as generally recognized as safe (GRAS) if its recognition of safety is based on the view of experts qualified by scientific training and experience to evaluate the safety of substances added to food. The basis for these views may be one of two.

1. Scientific procedures.

2. For those products in use in food prior to January 1, 1958, through experience based upon common use.

If a product was not in use prior to January 1, 1958, the only way it can be declared as GRAS is through scientific procedures. Furthermore, the results of the scientific procedures must be published so that they are generally known by qualified experts and subject to peer review. In other words, it requires common knowledge throughout the scientific community about the safety of the product.

Assuming there is adequate recognition of safety and no known hazard involved with the new food product, a person technically has authority to make the determination that a product is GRAS. FDA, on the other hand, has the authority to challenge that status. At best, this can create much apprehension on the part of the industry. At worst it can result in seizures and possible criminal action if FDA does not agree and decides to follow up. Furthermore, the food industry is becoming increasingly aware of these restrictions and rightfully asks the FDA status of an ingredient prior to incorporation into a food.

There is a provision, however, whereby a petition can be submitted to FDA to establish the GRAS status of a product or alternately, to establish it

as a food additive. Generally, there is not much difference between a food additive or a GRAS petition or the end result. Both require about the same amount of data.

If, after review of the petition, FDA believes that the intended use is safe but has some remaining doubts about extended use, they will probably classify it as a food additive and issue a regulation restricting its use to those mentioned in the petition. Even those products which FDA affirms as GRAS are now generally carrying with them certain use restrictions.

For those of you who have not yet been initiated into this procedure, you may be interested in a list of the types of information which has to be submitted in a GRAS petition or a food additive petition.

A. Name, identity and composition of the product. This usually includes some general outline of the manufacturing procedures and methods of control to assure its quality and purity. This would also include information on its chemical and physical properties.

B. Labeling. This section would include the intended use of the product and any restrictions on use.

C. Data establishing that it will have its intended effect. In the case of cottonseed products, the initial intended effect is, of course, to supply nutrients.

D. Assay method. This is generally required for chemical additives such as an antioxidants in which there may be restrictions, and proper control requires a method for determination of the amount of that additive in a food. This would not be particularly appropriate or needed for cottonseed products. However, assay methods for the presence of some potentially harmful components may be required. Gossypol may be a good example.

E. Safety data. This is the most detailed and most critical part of the petition. I would point out here that all data both positive and negative, should be submitted.

F. Tolerances, if necessary.

In addition, every petition would have to be accompanied by an environmental impact analysis determining whether or not there is any adverse effect on the environment from both the manufacture and use of the product. This has a whole different set of requirements which we don't have time to go into here.

When you submit a petition to FDA, you might want to consider the use of food product classes and categories of technical effects listed in FDA regulations Title 21 Sections 170.3(n) and (o) in establishing regulations for human use of cottonseed products.

Section 170.3(n) lists 43 categories of food products, such as breakfast cereals, baked goods, egg products, fish products, meat products in which additives may be used. You may specify a general category of food, such as "meat products" rather than a specific food, such as "hot dogs" and thereby increase the flexibility in use of the cottonseed product in different foods.

Section 170.3(o) lists 32 different technical effects such as formulation aids, nutrient supplements, stabilizers and thickeners, and texturizers recognized by FDA. Along with the use of categories of food products, your petition may specify general technical effects and provide more flexibility in end use of the product.

There is another area which you should keep in mind, and that is the availability of the data you submit to the public. The following information from a food additive petition is available to the public after a notice of filing has been published in the FEDERAL REGISTER.

1. All safety and functionality data.

2. Test protocols.

3. Adverse reaction reports, consumer complaints, product experience reports.

4. List of ingredients.

5. Assay methods.

The first three, of course, are of particular interest to the cottonseed industry.

The following are <u>not</u> disclosable to the public unless they have previously been disclosed.

1. Manufacture and quality control procedures. This information, however, is available if you have a GRAS petition. The concept is that if a product is generally recognized as safe, it is generally used, and the manufacturing and control procedures are generally known by the public.

2. Production, sales, distribution and similar information.

3. Quantitative or semi-quantitative formulas.

Before we leave the subject of petitions and their requirements, I would make one recommendation to you. Prior to investing a lot of time and money in research necessary to clear a product, discuss the protocols with FDA. It's true that you may, during this discussion, raise some questions which you would rather not raise. The chances are, however, they will come up at some point in time anyway, and it is better to know it before you start your research. Incidentally, it is not advisable to have preliminary discussions on fundamental research you do to determine whether or not you want to proceed with a particular product or project. I would be more concerned with those tests which you would do to document the safety of the product.

In the time I have left, I would like to direct a few remarks specifically toward use of glandless cottonseed meal for animals. I think you should consider applying a little different interpretation.

Cottonseed meal has been recognized and safely used prior to January 1, 1958, as a feed ingredient for animals. While the glandless cottonseed meal is produced from a different variety, it is my understanding that the meal

is produced by basically the same manufacturing procedures. Furthermore, definitions for low gossypol cottonseed meal recognized by the Association of American Feed Control Officials is broad enough to cover the glandless product. If you are content to use the terminology "low gossypol cottonseed meal" I think you would be justified in taking the position that the glandless cottonseed meal is generally recognized as safe as a feed ingredient and requires no further clearance with either the state feed control agencies or the federal government. If, on the other hand, from a marketing standpoint you believe that you would like to have a separate classification and separate name, the least you will have to do is contact the AAFCO cottonseed investigator - Billy Southall of Virginia. There is the potential, however, that Food and Drug may become involved and you may become involved in the same types of procedures I described previously. I would guess, however, that because you are dealing with an animal feed which is just as safe as, if not more so than currently used cottonseed meal, that it would not require quite the detail as would be required for human use. It is a point, however, that you should take into account.

In closing, may I thank you for inviting me. I have had to delete much of the detail, the whereases and wherefores and have just hit the highlights. I hope, however, that you understand the regulatory process a little better.

POTENTIAL UTILIZATION OF
NON-CONVENTIONAL PROTEINS IN FOOD PRODUCTS

By J. C. Lugay and M. Yuan

Today, as it was twenty years ago, there are only a few conventional protein sources that are readily acceptable by the consumer and food processor. These include meat, fish and shellfish, poultry, egg, and milk proteins. What these proteins have in common is quite obvious. The positive attributes are their nutritional and functional properties, while the negative ones are availability and price, when compared to the non-conventional sources. To the food processor, availability, cost, and nutritional and functional characteristics will determine whether a protein can be used in a formulation or not. It would, of course, be an ideal situation if these proteins were available in unlimited quantities and at an affordable cost. Because this is a hypothetical situation, the search for alternate sources of protein continues. The objective has been to identify other proteins that can be used to replace or extend the more conventional proteins as we know them now.

We recognize that protein is also present in vegetables, cereals, peas, beans, nuts, and to a very limited extent, in fruits; and all these could contribute to the overall protein need of the individual when included in the diet.

However, the area of greatest interest to the food processor is where he could deliver the best protein product, satisfying the nutritional and organoleptic wants and needs of the individual at the least possible cost. We would then need sources that could provide protein in a concentrated form, nutritionally adequate in composition, or at least one that can be balanced without much difficulty using other proteins and possessing functional characteristics that will permit use in a broad range of products. Probably no one protein can satisfy these requirements; but, usually, a combination of proteins from various sources could provide a tailor-made product with the proper nutritional and sensory properties.

Over the years, a number of non-conventional protein sources have been identified. Proteins from oilseeds, yeast, molds, bacteria, leaves, grains, algae, industrial waste products, and a hose of other sources were investigated. Many have been and still are laboratory curiosities. Others have reached the pilot plant stage. At this stage a number of proteins were pulled back because problems at the pilot stage were uncovered that were not evident in the laboratory. A very limited few have gone into commercial-scale production. An example of the latter is soy

protein, and I do consider soy a non-conventional source of protein. Yet, at the present time we're not really using non-conventional proteins to the extent that we could. For example, we're only using less than 2% of the soy protein production for human food. The question is, "why"? The same question can be asked of all protein sources: oilseeds, grains, cereals, peas, beans, single-cell protein, leaf, etc.

A number of requirements must be satisfied before a protein can be considered acceptable for use in a product for national distribution by a major company. The following factors must be considered: availability, cost, functional properties, flavor and aroma, nutrition, absence of toxic constituents, and compatibility with other food ingredients.

I would now like to discuss very briefly how each one of these factors could influence the utilization of non-conventional proteins in foods.

A. Availability

It is quite obvious that, if a protein source is not available in quantity to the food processor, it will not be used in a product. It should not just be available, but it should be available in a form he can use; i.e., it should be in the form of a concentrate, isolate, or flour if the protein concentration is adequate. It would be very difficult to use a material as a protein source if the protein concentration is low (less than 20%) not because the protein is not a good protein; but other components associated with the material could and usually do interfere with the formulation of the product. Therefore, the investigator should consider very early in his studies how to deliver this protein in a concentrated form. If the protein is not available now, it should at least have a realistic future, whether it is five, ten, or fifteen years from now. There have been instances in the past when a protein's potential has been overestimated and, consequently, oversold, sometimes as the "salvation of the world." Examples are numerous, including single-cell protein, leaf protein, fish protein, and certain oilseeds. Unfortunately, some very key elements have not been taken into account, such as the process not being clearly defined for scale-up or an inconsistent product quality or the need for some regulatory action. Any and all of these factors could result in the product not being available to the processor.

I would like to suggest that, when novel non-conventional proteins are identified for investigation and eventual use, the investigator immediately make an assessment, as best he can, as to how realistic this protein source is. If unavailable here and now, what would it take to make it available and how long. In this manner a program can be laid out in proper perspective, recognizing the rate at which progress can be made in a given time frame. In this manner the expectation of the food processor is in line with the actual progress being made by the investiga-

tor and raw material manufacturer in bringing the protein to market.

B. Cost

Cost is probably the most variable factor and, therefore, most difficult to project. We just can't predict what could happen in the future that could have a drastic effect on raw material cost. We can, however, mention one very important requirement about cost: it must be competitive with the price of the protein we're trying to replace. If someone is selling an egg albumin alternative today, it cannot be sold for greater than $2.40/lb. If it does not have all the attributes of egg white, it probably would be competitive at a price much less than $2.40. Five years from now, it might be possible to sell an egg white replacer for $2.40, depending on what the price of egg white is at that time. It is possible to sell an egg white replacer at a price greater than egg white if the property is such that the processor will be able to use less of this replacement when compared to egg white. In effect, the processor is buying the functional property of egg white on a weight basis. At $5.00/lb., if it's three times as effective, it's cheaper than a material at $3.00/lb. We are assuming, of course, that the nutritional requirement of the formulated product will be satisfied.

C. Functional Properties

A major barrier to protein utilization in food is the lack of certain functional characteristics. There are two reasons why the food processor will put protein into a product: (a) for nutritional purposes and (b) for functional reasons. We can deal with the nutritional requirement in a very straightforward manner. We generally know how much protein is adequate for a given product. If the protein is nonfunctional and does not contribute to the food's major textural attributes or contributes only to a very limited extent, then the addition of protein material will not present serious complications. If, however, the protein plays a major role in the rheological or textural property of the food product, then the functional properties of the protein must be taken into account. There are a number of "functionality" reasons why a protein will be accepted/rejected for use in a food product. In this instance the specific requirements of the food product must be taken into account. For example, if a protein is needed for incorporation into a high-protein beverage, then a number of questions must be answered:

(a) is it a clear beverage or is it cloudy?
(b) how much protein is required?
(c) what is the pH of this beverage?
(d) what is the ionic environment or buffer system?

(e) is it to be a shelf-stable beverage or is it to be refrigerated?

After these questions have been answered, some proteins will survive but most will probably be eliminated from further consideration unless certain deficiencies could be corrected; for example, hydrolysis to improve solubility at low pH.

If a product requires a protein with binding and heat-setting characteristics, then fish protein concentrate, as we know it today, will not be satisfactory; but probably a modified fish protein concentrate, or a functional soy isolate, will be a better choice. If a modified fish protein concentrate is used, the type of modification, such as the introduction of functional groups to improve its solubility and gelation, will probably require some extensive testing to prove its safety and that the nutritional properties are not affected. On the other hand, if the product needs protein only for its nutritional contribution, most animal proteins will be satisfactory and usually mixtures of plant proteins or plant and animal protein combinations will suffice, provided the other factors are taken into account.

Another functional property of proteins very important in some foods is film formation as exemplified by the emulsification properties of some proteins. Now, this can be a rather misleading property. Some proteins are claimed to have excellent emulsion capacity. However, this information is usually not sufficient to predict how well the protein will hold and release fat or oil in a food system. Usually, emulsification tests are carried out at rather low protein concentrations; but, more realistically, the emulsion property at high protein concentration is more meaningful for most food application. Extending this argument further, functional property data that have been carried out under conditions that more closely simulate real food systems are more meaningful to the food processor. It facilitates extrapolation to actual product applications.

Another important property of proteins is what I would call "texturizability", for want of a better term. There now exist only a very few basic methods for texturizing proteins: extrusion, spinning, and, more recently, freezing. Most of these methods are aimed towards making animal tissue-like material. All other approaches to texturization are just variations of the same basic processes. At the present time knowledge on the basic protein interactions taking place during texturization is very meager. Hence, the approach being taken to control protein texture is rather empirical. Better understanding of protein interactions could lead to better control and, consequently, superior texture. The same can be said of processes involving heat treatments. A clearer understanding of these interactions could provide us better flexibility and control during processing of proteins. Other important functional properties are hydration properties and water-holding capacity. All these functional properties provide the processor with options, when to use the proteins and how to use them.

D. Sensory Characteristics

A major reason why some proteins are rejected for use in foods is their unacceptable sensory property. A protein may have a dark color, objectionable aroma or taste, or bad texture in the final product. If these deficiencies cannot be corrected by formulation changes, then the protein will be rejected. It is essential at this stage to provide a protein with a minimum of color and odor/aroma/taste. It will facilitate the processor in using the protein in a broad range of products. For example, it would almost be impossible to use leaf protein unless the color were eliminated. At the same time it would also be difficult to use the whitest fish protein unless the fishy odor were eliminated.

E. Nutrition

I mentioned earlier that nutrition can be handled in a fairly straightforward manner by the food technologist as long as he has the necessary information on the nutritional quality of the protein. By mixing several proteins at the appropriate ratios, the proper amino acid balance can be achieved. Here, we are assuming that antinutritional factors are eliminated by the time the food processor is ready to use the protein.

All of the above properties must be satisfied for a given food system before the non-conventional protein can be successfully utilized. The complexity of foods is compounded by the fact that proteins interact with other components, such as fats, carbohydrates, salts, and flavors. Any adverse reaction that could take place with these ingredients during processing must be eliminated before the non-conventional protein could be used.

Finally, the ultimate test for a non-conventional protein is consumer acceptance in a food product. All functionality tests, process manipulations, chemical, enzymatic, or physical modifications are for naught if the consumer rejects the protein product for any reason whatsoever. A major responsibility falls on the shoulders of the food processor to make these proteins acceptable in products desired by the consumer. At the same time, the protein investigator, the person who is advocating the use of specific non-conventional proteins, must have most of the questions I've raised answered in order to provide a true and realistic picture of the potential these proteins really have.

MARKET POTENTIAL FOR GLANDLESS COTTONSEED PROTEIN IN DAIRY PRODUCTS

By M. D. Wilding

Before considering the market potential of glandless cottonseed protein, let us position dairy products as a nutrient source in the American diet.

Dairy products supply an important portion of the nation's protein, calcium, phosphorus, and certain vitamins. They supply 22% of the per capita consumption of protein, 75% of the calcium, 35% of the phosphorus, and most of the Vitamin D (Table 1).

A favorable biological protein output to feed energy ratio of ruminant milk production exists compared to other animal protein sources. This relationship should give additional encouragement to the use of dairy products as a food and the use of vegetable protein in this important food system.

In the last 40 years, the percentage of protein in the U.S. diet coming from dairy products has not changed. In the 1935-39 period, the percent of protein coming from dairy was 21.1% and 29.4% derived from meat, poultry and fish (Figure 1). This constituted approximately 50% of the total dietary intake of 90 grams of protein.

In 1975, the percent protein in the diet supplied by dairy products was 21.9% and 41.6% coming from meat, poultry, and fish (Figure 2). This combined percentage has increased to 63.5% of the total protein intake of 101/grams with a concurrent decrease in the traditional vegetable sources.

Now let us turn our attention to the changes that are projected for the availability of milk for the manufacture of various dairy products. Historic trends over the past 15 years show a sharp increase in cheese consumption from 8.3 to 14.6 pounds per capita. The consumption of total fluid milk solids, milk fat, nonfat dry milk, and butter has decreased.

In order to estimate availability of milk for the future, it is necessary to study recent trends of population growth, milk prices, milk supply, and demand and the utilization patterns.

POPULATION TRENDS

It is estimated that the world population will grow from four billion (as of March 1976) to nearly seven billion by the year 2000. If these projections materialize, the world population will double in 40 years. This will place a severe demand upon our ability to provide an adequate food supply for these increased numbers of people. Of the total world population, about 5.4 billion (77.5%) will live in the less developed countries. This will place a disproportionate strain on these already poor countries (1) to adequately supply food and protein to their people, and (2) to pay for this food supply. If these food needs are not met, serious world crises are destined to result. The use of vegetable protein, such as glandless cottonseed, can greatly assist in providing essential nutrients at a lower cost, not only in the U.S., but in these developing countries.

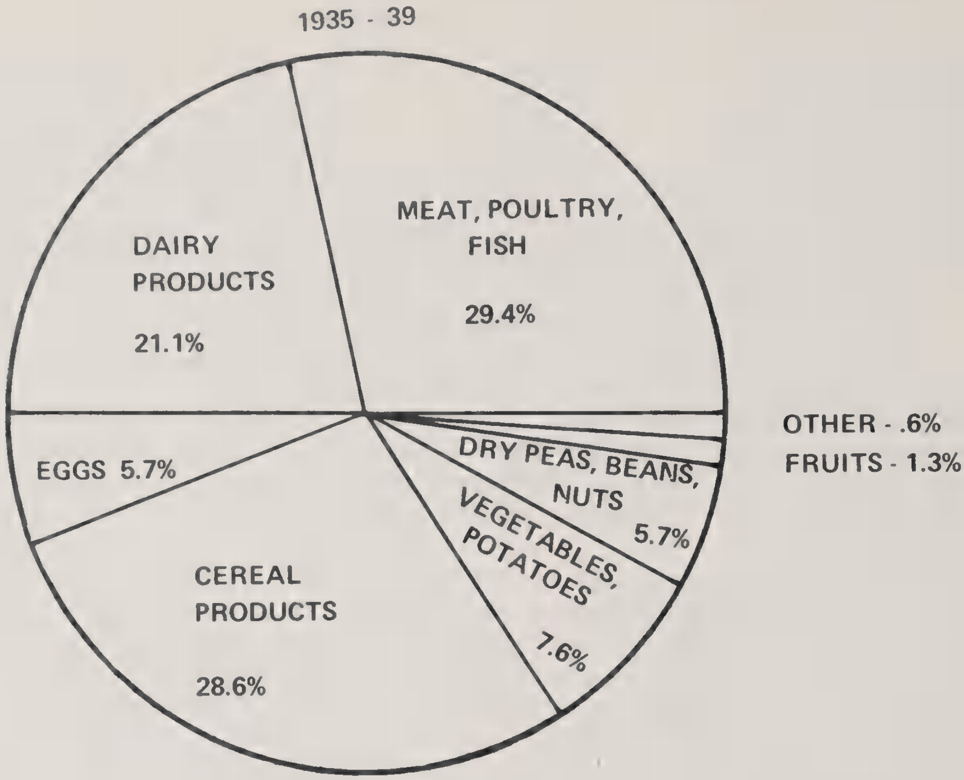

Figure 1.--U.S. dietary protein distribution by food groups, 1935-39.

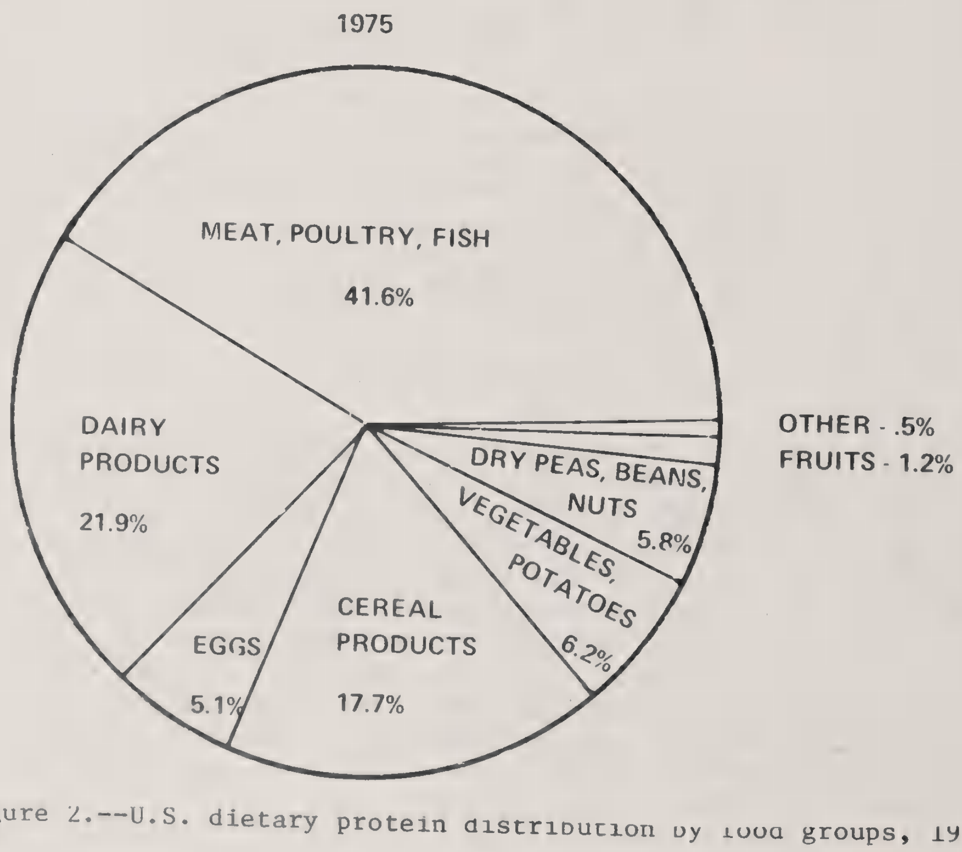

Figure 2.--U.S. dietary protein distribution by food groups, 1975.

DAIRY PROTEIN AVAILABILITY AND TRENDS

There has been a two and one-half fold increase in the price of manufacturing grade milk since 1965. Before 1965 (Table 2), the pricing structure was relatively stable. All indications suggest this upward trend will continue.

If we project these recent changes to the year 1985 (Figure 3), we observe it is likely that a two-fold increase in the price for manufacturing grade milk could occur.

Table 3 shows a comparison of the last seven years. Here we observe that nonfat dry milk solids have increased from 26¢/pound to a high of 63½¢/pound, butter has remained stable at a price of 69¢/pound until the last 2 years and then increased to 92¢/pound, and cheese has increased from 55¢/pound to a high of 96½¢/pound. There are many factors which are causing the price of milk and the products manufactured from it to increase. Let's examine some of the historical milk production patterns and other factors affecting supply and demand.

During the past 26 years, milk cows on farms have decreased from approximately 22 million to 11 million (419,038 cows/year). During the same period, annual milk production per cow has increased from 5134 pounds to 10,893 pounds/cow (Table 4). This large increase in productivity per cow has nearly maintained milk production but with a slight overall downward trend. Since 1965, overall milk production has decreased by 3% while total food consumers have increased by 11.5%. Traditionally, total milk production has kept pace with population growth.

If we compare population growth and the demand for protein products against the decreasing trend of total milk production (Figure 4), the widening gap becomes very significant after 1980, providing current trends are not reversed by other factors. The erratic fluctuations occurring in the actual production values are caused by many factors, such as the demand for milk, price and availability of feed, weather, foreign markets, etc. The heavy rigors of dairy farming have become less attractive to the younger generation vs. an 8-4 factory job. Once a decision to go out of the dairy business has been made, it is difficult to again get back into the business because of the large financial commitment involved (upwards of $250,000).

In recent years, the relative prices received by dairy farmers have been lower than other farm products (Table 5), particularly during the 1972-73 period. This lower price incentive may have been partly responsible for the lower total milk production.

During the past 27 years, the population growth slowed somewhat compared to per capita disposable income. This 4-fold increase in disposable income has allowed the consumer to purchase higher priced dairy products. The purchasing patterns have shifted from a decreased milk fat and nonfat dry milk solids to a doubling of cheese consumption (Table 6).

Relating all these factors, the following trends appear likely over the next 10 years:

1) There is some indication of a decline in milk production.
2) The U.S. population is estimated to increase by about 10-15 million people.
3) The average person will have higher per capita disposable income.
4) The per capita consumption of milk fat, nonfat milk solids will decrease only slightly.

(Continued on page 61.)

TABLE 1.--Nutrients supplied by dairy products in the U.S. diet in 1975

	PERCENTAGE
PROTEIN	22.0
FAT	13.2
CARBOHYDRATES	6.7
CALCIUM	74.5
PHOSPHORUS	34.7
MAGNESIUM	21.1
RIBOFLAVIN	39.8
VITAMIN B_{12}	19.8
VITAMIN A	12.7
VITAMIN B_6	10.2
THIAMINE	9.0

TABLE 2.--Average prices received by farmer per hundredweight for milk eligible for the fluid market and manufacturing grade

	MILK ELIGIBLE FOR FLUID MARKET	MILK MANUFACTURING GRADE
1950	$ 4.36	$ 3.16
1955	4.50	3.15
1960	4.69	3.25
1965	4.63	3.34
1970	6.05	4.70
1972	6.38	5.08
1974	8.66	7.13
1975	9.02	7.63
1976	9.93	8.56

TABLE 3.--Comparison of the market prices of nonfat dry milk solids, butter, and cheese per hundredweight from 1970 to 1976

	1970	1971	1972	1973	1974	1975	1976
NFDM	$ 26.31	30.74	33.06	46.38	58.62	63.32	63.50
BUTTER	69.43	68.35	68.60	69.75	65.72	79.38	92.03
AMERICAN CHEESE	54.95	56.48	59.82	72.63	79.89	86.61	96.30

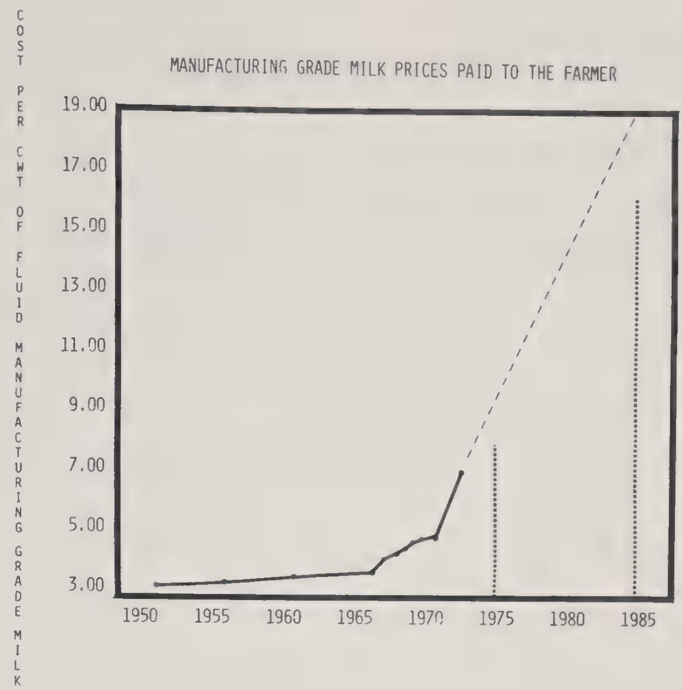

Figure 3.--Plot of actual price of fluid manufacturing-grade milk per hundredweight from 1950 to 1974 and a projection of the increase in price from 1970 to 1974 extended to 1985.

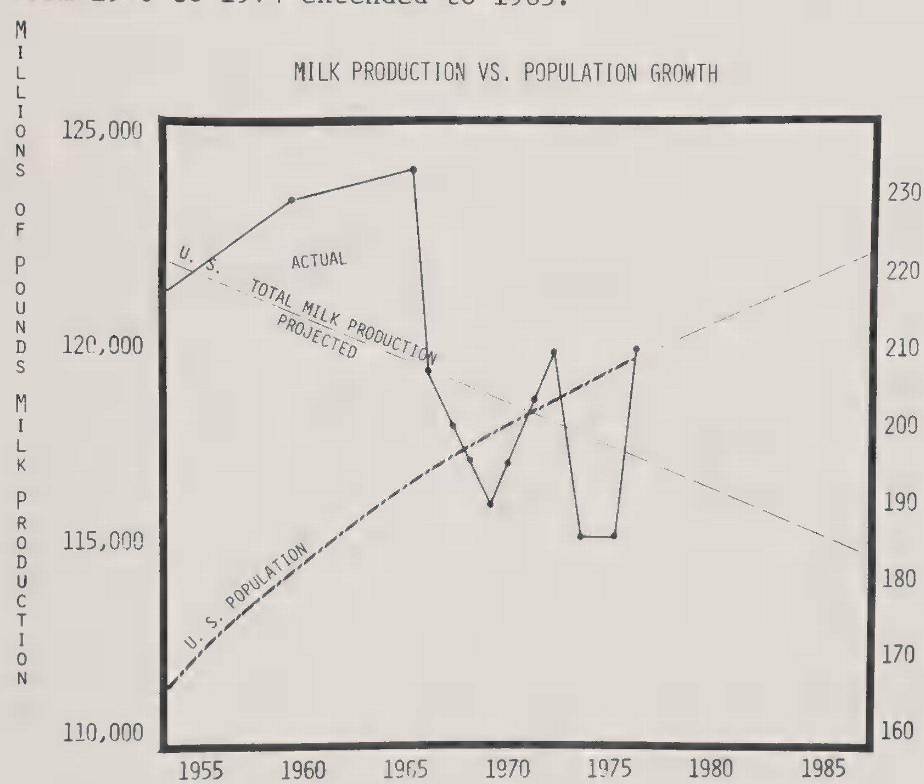

Figure 4.--Comparison of the actual and projected total milk production vs. U.S. population growth.

TABLE 4.--Trends from 1950 to 1976 of milk cows on farms, milk production per cow, and total milk production in the U.S.

	MILK COWS ON FARMS AVERAGE DURING YEAR (000)	MILK PRODUCTION LBS. PER COW	TOTAL (MM LBS.)
1950	21,944	5,314	116,602
1955	21,044	5,842	122,947
1960	17,515	7,029	123,109
1965	14,953	8,305	124,180
1970	12,000	9,747	116,962
1975	11,140	10,352	115,326
1976	11,049	10,893	120,356

TABLE 5.--Relative prices received by dairy farmers vs. all farm production. 1967 is used as the base year

	DAIRY PRODUCTION	ALL FARM PRODUCTION
	(1967 = 100)	
1950	81	102
1955	81	91
1960	84	94
1965	85	98
1970	113	110
1975	175	185
1976	192	186

TABLE 6.--U.S. population, disposable income, and per capita consumption of milk fat, nonfat dry milk, and cheese during the 1950-77 period

	TOTAL POPULATION (Millions)	PER CAPITA DISPOSABLE INCOME (Dollars)	PER CAPITA CONSUMPTION MILKFAT (Lbs)	NFDM (Lbs)	CHEESE (Lbs)
1950	151.7	1,364	29.3	43.6	65.4
1955	165.3	1,666	27.2	44.5	67.1
1960	180.7	1,937	24.5	43.4	70.5
1965	194.3	2,436	22.9	42.9	77.4
1975	213.6	5,062	20.1	38.1	123.7
1976	215.1*	5,493*	20.1	39.1	136.5*
1977	216.8*		20.1		

*Preliminary

In the future, we can see some shifting of milk utilization to beverage use. If this occurs, we see a greater need for alternate protein sources to extend manufactured milk in the utilization of cheese and other dairy products.

DEVELOPMENT & USE OF ALTERNATE PROTEIN SOURCES TO EXTEND THE MILK SUPPLY

If the above projections are reasonably accurate, the need for good quality functional vegetable protein sources is obvious. Some of these protein sources will undoubtedly come from glandless cottonseed. We have found that cottonseed protein has some interesting and unique properties for the dairy products area.

One of its greatest limitations is the off-color properties in the resultant product. This is particularly noticeable in dairy products. Glandless cottonseed flour is obviously very low in gossypol content by comparison with glanded seed. Glandless seed has some contamination pigments that cause some brownish green off-color in light colored dairy products. Chlorogenic acid is another component of glandless cottonseed that produces color responses in food systems. These pigments act like a pH indicator in certain food products. Additionally, there are natural flavonoids that impart a yellowish color; however, these are less objectionable in dairy products than the greenish-brownish color responses. It would be desirable if these components could be lowered in cottonseed either by selective extraction or genetic control.

Any search for or consideration of a new alternate protein source must (1) be organoleptically acceptable in a given food system, (2) have the basic nutritional qualities or have a synergism with another protein to produce an equivalent food value in the resultant food consumed, (3) it must be readily available or have a growth potential, for it to be considered very seriously as a protein alternate. Undoubtedly, this has been one of the limiting factors affecting the usage of glandless cottonseed by many companies. It is uncertain how rapidly this protein will become available for commercial use, and (4) it must be lower in cost than conventional sources and competitive with other alternates, such as soy or peanut, etc. If a given protein source has special properties of flavor compatibility, functional performance in a food system, or color properties, the cost difference will be equated against these properties.

Many of the standard tests for functionality are of little value unless they can be correlated with the desired textural characteristics of the real food system.

Milk protein, when incorporated with vegetable proteins, such as glandless cottonseed, improves protein quality because it provides lysine and methionine, the two most limiting essential amino acids in most vegetable protein sources. A synergistic effect often can be obtained to increase protein quality and functional performance in a food when two different protein sources are used together.

In the dairy products area, several companies are actively pursuing the development of imitation forms of cheese and other dairy products. They are called imitation because they fall outside the product standards of the traditional food being imitated. However, in all likelihood, these standards will be changed to accommodate alternate protein sources as these new product forms are developed and achieve marketing success. If the current thinking on restricting the imports of casein is implemented, this could markedly affect the need for soy, cottonseed, peanut, and others in this non-standard dairy products area.

As one puts in perspective the above factors and changes that are now occurring, we will undoubtedly see a greater utilization of unconventional protein sources supplying the total dietary protein needs of the world population.

MARKET POTENTIAL FOR BAKED PRODUCTS CONTAINING PROTEIN INGREDIENTS

By Bruce R. Stillings

INTRODUCTION

During the past ten to fifteen years, protein ingredients have received a considerable amount of attention by nutritionists, technologists and politicians. In some cases, more resources have been expended in development and use of proteins than might be justified by the need for protein and by the expectations for practical application. This has occurred partly because of insufficient input from all the disciplines needed for successful development. In particular, one characteristic that is common to protein projects that have not been successful is lack of sufficient marketing input at an early stage of development.

Thus, in this paper, I would like to highlight the main reasons for using protein ingredients in foods and some of the potential market opportunities for protein foods. Then, based on these potential markets, we'll touch on the important criteria for selecting protein ingredients and the potential for glandless cottonseed protein. In regard to protein foods, comments will be limited mainly to baked products, since other speakers will cover other product categories.

A. Reasons for Using Protein Ingredients in Foods

Protein ingredients are used in foods for two basic reasons: (1) nutritional and (2) functional.

1. Nutrition

Programs to develop and use proteins for nutritional purposes received tremendous support in the 1960's. Protein malnutrition was identified as the main nutrition problem in developing countries. As a result, millions of dollars were spent to develop and use so-called unconventional protein sources, such as soy, cottonseed, peanut, single cell protein and fish protein concentrate. It is interesting to note that now, a decade later, soy is the only one of these proteins that is established in the human food market, and it is often used for functional rather than nutritional purposes. We shall examine some of the reasons for this later.

In the early 1970's, nutritionists re-examined the premise that protein deficiency was the main nutrition problem in developing countries. The results showed that lack of <u>food</u> was the

most critical problem. Furthermore, basic staples such as rice and wheat could provide sufficient protein for the bulk of the population, without protein supplementation. Exceptions include infants and young children who need additional protein for optimum growth. Thus the "protein problem" in developing countries shifted to a "food problem," and the emphasis and need for protein ingredients were diminished.

In the U. S., a report published in 1968 called "Hunger USA" charged that malnutrition was rampant and that protein deficiency was a serious problem. This was followed by the Ten State Nutrition Survey; The White House Conference on Food, Nutrition and Health; and the Health and Nutrition Evaluation Survey (HANES). These activities put the nutrition problem and its causes into better perspective. The results showed that, although there are nutrition deficiencies in the U.S., protein is not a major problem. In fact, in some population groups, mean intake of protein is two times the recommended daily allowance.

The bottom line of the protein issue is that we have more than enough protein available for consumption in the U.S., and in developing countries the need for more protein is considerably less than that estimated a decade ago.

2. Functional Properties

Proteins are used for their functional properties in numerous food products. In fact, proteins are used for this reason to a considerably greater extent than for strictly nutritional purposes. Some of the more important functional properties include:

. Solubility and dispersibility in water

. Stability at high and low temperature and pH

. Degree of fat and water absorption

. Emulsion formation and stabilization

. Gelation and texturizing properties

. Color control through bleaching and browning

. Aeration properties, particularly in baked goods and whipped toppings.

B. Markets for Protein in Baked Products

Based on the premise that proteins are and will be used in foods for either nutritional or functional reasons, the question is "what are the present and potential markets for protein products?" As previously mentioned, we will consider mainly

baked goods. Also, since market opportunities differ between the U.S. and the developing countries, each will be considered separately.

1. U. S. Markets

As discussed earlier, protein intake in the U.S. is generally more than adequate. Thus, there is no general need or large scale market demand for protein-fortified baked foods.

Further, the addition of more than small amounts of protein to baked goods generally detracts from their physical and sensory characteristics rather than enhancing them. Milk protein is added to bread for flavor and color, but the amounts used are generally small except for high-protein breads. For nutrition and functional reasons, therefore, the market potential for additional wide scale use of protein ingredients in baked goods is low. There are, however, specific product areas that do offer promise for further market development, and some of these are identified below.

Products marketed for infants and young children - should deliver balanced nutrition, including protein, at least in proportion to the caloric content. In fact, FDA encourages protein fortification by requiring that products promoted for infants contain protein with a quality at least 40 percent of that of casein. If the quality does not meet this standard, the protein (as percent USRDA) must be listed as zero on the label with a statement that the product is "not a significant source of protein." To meet these requirements, wheat-based products must be fortified with a higher quality protein.

Snacks designed to replace main meal items - should deliver nutrition comparable to that in the items being replaced. The traditional three meals per day is being replaced by several small meals, or snacks, consumed throughout the day. To a large extent, these snacks are convenient, highly palatable, manufactured products. They should also be nutritious. As our dietary habits change further in this direction, I believe that market opportunities will increase for snacks that contain balanced amounts of vitamins, minerals, fiber and protein. This represents another potential market for protein ingredients.

Protein-fortified products for general retail sales - may gain additional favor in the future. As consumers become more nutrition conscious, market demand will likely increase for nutritious items in product categories that may not be generally perceived as being nutritious. For example, certain brands of bread and snacks are being fortified and promoted on a nutritional basis. This trend will likely increase to provide consumers with a nutritional choice in each product category. It is unlikely, however, that there will be any large-scale fortification, especially with protein, of products.

School feeding programs - may offer market opportunities for protein foods, particularly if meal requirements are changed from requiring minimum amounts of certain commodities to requiring minimum amounts of nutrients. Unfortunately, USDA proposed recently to withdraw approval of formulated grain-fruit products, which are among the few presently allowed that have nutritional standards. It is interesting to note, however, that New York City plans to introduce nutritionally fortified fast foods into the schools. The philosophy is that it's better to offer nutritional foods that kids like, rather than the basic-four foods that traditional, nutrition educators like. In summary, opportunities may develop for protein-fortified foods in the school feeding programs. Food Manufacturers, however, will have to decide whether the potential markets will be worth putting up with the bureaucratic red tape.

Special dietary products - will likely become increasingly important, and protein ingredients will be needed to meet specific nutritional needs. Products in this category include those for geriatrics, certain disease conditions, weight reduction, surgical patients, etc. This is an area that is particularly attractive for marketing protein products.

2. Developing Countries

There have been several classical attempts to market nutritious, high-protein foods in developing countries. Most have failed because of low market demand by consumers and failure of local governments to support food and nutrition programs.

Government support for these programs seems to be improving, especially in middle eastern countries that have an abundance of petroleum dollars. Higher priority is being given to school feeding programs. As a result, there are market opportunities for fortified baked goods. The competition for these markets, however, is keen. Also there tends to be a preference for using locally produced ingredients instead of imports. Thus, although there is market potential for protein foods in developing countries, the greatest opportunity for U.S. food companies is probably in supplying technology for producing these foods through joint ventures with local companies or governments.

C. Criteria for Selecting Protein Ingredients

After specific products have been identified that require the use of protein ingredients, the most appropriate source or combination of protein sources must be selected. Selection will depend, of course, on the intended end use as well as several other factors that are highlighted below.

Functional properties - protein must contribute the desired functional characteristics to the product or, if used for nutritional purposes, it should not detract from the desired characteristics of the product.

Nutrition - if used for nutritional purposes, the quality of the protein, either alone or in blends, must be sufficiently high to meet nutrition objectives of the finished food product. The protein source should also not contribute to digestive disturbances when consumed.

Sensory characteristics - the protein should not impart undesired flavor, color or texture to the product.

Safety - protein source must be cleared for intended use by regulatory agencies and should be perceived as being safe and wholesome by consumers.

Price - cost must be competitive with other protein sources, unless special attributes justify a premium price.

Availability - the protein source must be available in sufficient quantities to meet projected market demand.

The above points highlight the ideal characteristics that proteins should have for use in products. Since no one source will meet all criteria, there obviously will be trade-offs. Approval by regulatory agencies, however, is essential; and if other factors are comparable, price becomes a dominant factor.

D. Potential for Cottonseed Protein in Baked Products

Based on the criteria for selecting protein ingredients, I would like to briefly examine the potential for using glandless cottonseed protein in baked products compared to soy and milk proteins, which are presently the two main competitors.

From the standpoint of functional properties and protein quality, cottonseed protein compares well with soy and sometimes better. The protein quality is slightly higher, and cottonseed has less flatulence. Milk protein has a broader range of functional properties and a higher quality protein. In regard to sensory characteristics, higher amounts of cottonseed than soy can be used in products without causing undesirable flavor changes. Also cottonseed flour can impart a desirable creamy, yellow color in products and reduce the need for color additives.

Glandless cottonseed protein presently has two major obstacles to overcome. The defatted flour may require additional approval by the FDA (Food and Drug Administration), and commercial quantities are not available for use. FDA has indicated that future petitions for extended uses of glandless cottonseed, beyond the use of roasted kernels, may require additional studies supporting safety commensurate with level of usage requested.

Studies to satisfy the FDA could be expensive and time-consuming. At the same time it may be difficult to convince a processor to build a commercial extraction plant to produce product for human use until the product is cleared for food use. Beyond these two obstacles, the main question is will cottonseed flour compete economically with other sources of protein? Cottonseed flour has a few advantages over soy flour as noted previously. These advantages, however, would still not command a significantly higher price than soy. Cottonseed protein should, however, compete favorably with milk protein. If, as expected, supplies of milk protein decrease and prices increase, markets for cottonseed protein should become more favorable. In combination with soy and cereal proteins, cottonseed protein could partially replace milk proteins in baked goods. In addition, the longer term markets for textured cottonseed protein in processed meats and other products appears especially favorable.

SUMMARY

A more realistic approach to the need and markets for protein ingredients must be taken in the future than was followed in the past. Future markets for expanded use of proteins in baked goods appear limited, but opportunities exist in specific product categories. Markets for glandless cottonseed protein appear promising if FDA regulations are met, commercial quantities become available, and price is competitive with other sources.

VIEWPOINTS AND DISCUSSION

The Grower's Viewpoint

By E. Hervey Evans

Thank you Mr. Cavanagh. All I can say is that the situation is confusing. One thing has come out of these sessions today. Not only do we have a chicken and egg proposition, like Garlon Harper stated to start with this morning, but we've got many chickens and we've got many eggs. I don't know where we're going to start, but we obviously have some problems to narrow down and try to get a hold on. I noticed we panelists were billed as being here to give reactions. On a humorous side, I would like to say that when Dr. Lusas showed us his slides of those wonderful tasty products made out of glandless cottonseed protein that take so many different delicious forms it really worked me over, because we started off this morning with a breakfast that consisted of a little Danish pastry and some orange juice, and I thought, "where is all that good cottonseed food that we need?" We surely could have used them at that point.

On a serious note, I think one of the things I would like to react to, to start with, is to say that the very fact we are having this meeting here today, with so many people represented from broad, industrial and technological backgrounds, all the way from the basic agricultural production segment, from plant breeding through manufacture of food products and all phases of research, is the most hopeful sign that I can think of. It marks, I think, a real milestone in the development of efforts to do something about glandless cottonseed in making it a commercial reality. In our own company, we have been doing developmental work on glandless cottonseed varieties for some 16 to 17 years. As in the case with the other people in the breeding industry, I think there are pretty good commercially available varieties today that stack up well in terms of yield, in terms of good agronomic characteristics like fiber properties of the lint and maturity and those kinds of desirable attributes, and yet, we don't see anything happening. We don't see much going on to get glandless cottonseed launched into a commercial reality. The fact that we are here today addressing ourselves to these problems is a most hopeful sign.

Obviously, we've got to deal with questions of economic incentive. A number of the speakers this morning and this afternoon have addressed themselves to the economics from the food systems viewpoint. From a broader viewpoint, we also have a problem of economic incentives to the growers themselves. And this is where one of the chicken and egg questions arises. How are we

going to get the process started unless we get some production? I think one of the problems is you cannot expect cotton producers to make a wholesale shift from varieties they are growing unless there is some economic incentive for them to do so. So you've got the question of what market forces are going to bring this about. I rather like, I think, one of the things I heard Mrs. Martinez say and that is maybe we've got to think first in somewhat smaller terms and perhaps, get some small operations going, maybe on a limited scale. We've got to get some production going, perhaps on contract with farmers by providing some economic incentive, and maybe starting such small operations as specialty dehulling operations in order to provide, first, more understanding at the farm production level of what we're going to be dealing with in the production system. In our own operation, we have been growing glandless cotton varieties as part of a breeding effort with reasonably good-size commercial increases. These never have been marketed as cottonseed but have provided reasonably adequate production experience. In general, we have found that as we follow our regular production system, which in the Southeastern part of the country is based on high levels of insect control programs, we come out generally pretty competitively with the production of our standard varieties. But, we are a long way from having seen this production system translated into a large-scale commercial effort. That is to say, what we are seeing at the 10 to 50 acre production level we're not that confident about yet if we were to move to the 500 to 5,000 acre production level. Until we can get a little more confidence on those questions, I think we really don't know yet all the answers. Here again, I think, in order to take those risks somebody's got to take the lead in tieing the production phase in with the market phase by giving some economic incentive to farmers who are willing to be creative and take the initiative to see what can be learned, at least, from a limited commercial production program.

Now, obviously, one of the things that comes out of the program this morning is that if we were to get into some of these large-scale food processing systems and even into the oil mills there would be some major capital investments involved. Just looking at it from a practical business viewpoint it is hard for me to imagine that those steps are going to be taken and those capital commitments made until there is enough of a level of confidence at the grower level on production that we can expect the supply to be there when those capital investments are made.

One of the things that struck me also is the real possibility from what several of the speakers, including Dr. Wilding, said that there may be initially some greater demand for cottonseed protein products in the less developed countries of the world than here in the United States. In our own experience, we have been contacted by more people outside the United States than we have from people in the United States who have been trying to figure out what is available in the way of glandless cottonseed varieties. While that may be their interest at this point, I still think commercialization is a long way from being a reality. No doubt, less is known about production problems in the kinds

of production situations encountered in other countries than we know about production problems with glandless cottons here in the United States. I remember one of my first experiences with glandless cottonseed was walking along some individual rows of cotton, both glanded and glandless, at the Iguola Station in Mexico, where the cottonseed breeders typically send material for winter increase, and noticing a single row where all of the cotton on that row had already been harvested and deposited in neat little piles at the base of the plant. I couldn't figure out what that was until we examined closely and found out that it was a glandless row. The rats had done a better job of selecting it than anybody else--they had gotten right in there and figured out which one of those rows was glandless, had harvested the cotton and eaten the seed and left the lint right there at the base of the plant. What that means in terms of production systems if you were to go to some place outside the United States like India or the Sudan or some place like that I don't know, but it sure points up that there are some unanswered questions about the production system that would have to be found out. I would like to just close, Mr. Cavanagh, by saying that I would hope in the process that, if the economic returns down the road look pretty good, one of the things some of our friends in industry might take a look at is a possibility of convincing their management and their Boards of Directors that a little economic incentive with farmers to get the production system started might be viewed and classified as R&D money so that we can get something off the ground that way. Then I think we will move the process along a little further. Thank you.

The Ginner's Viewpoint

By J. S. Francis, Jr.

Thank you. I can recall well when Mrs. Martinez called me and invited me to come here to Dallas. I am delighted to be here. As I look back on the invitation, I can see that it was my ego that responded. I am happy to report that my ego is now completely under control, after being up here with all of these Ph.D.'s. It's very difficult to get me humble, but you are seeing it today.

Mrs. Martinez, I congratulate you for calling me so far ahead. I'll say "yes" to anything two months away.

I am going to assume, although I know there are some exceptions, that the cotton ginning industry is not very well understood by most of you. There are about 3500 cotton gins in the United States and this year we are producing about 14 million bales. That means those 3500 gins are going to average about 4000 bales of cotton. I had to sit down and compute how many tons of seed they were going to process -- about 1600 tons -- because to a cotton ginner, and I think to a producer, the primary interest is obviously focused on the lint. The lint is worth 40¢ to 50¢ a pound and the seed is worth only 3¢ or 4¢ per pound.

Mrs. Martinez rather adroitly has figured out that most of what we do in a cotton gin is not the ginning process. It is, in fact, the rather inefficient handling of the material which we bring into our plant, which is about one-third lint, about 50 percent seed and the balance is moisture and foreign matter.

We take all this into the plant at rather rapid rates and we end up spending less than 20 percent of our used horsepower in the actual ginning process. About 80 percent of the horsepower is used to prepare the cotton for ginning, cleaning it and packaging.

The seed is handled in accordance with its value, which means it isn't really handled by most of us ginners in a very satisfactory manner. I can certainly see we would have to change this with the advent of glandless cottonseed.

Even with the difficulties of handling glandless cottonseed, we must resolve the problems. The cotton industry needs desperately to have more value for our product than we can demand from the lint, because of the intense competition that we have with synthetics.

There will not be a lot of problems, from a ginner's point of view. Perhaps I am over-simplifying it and I am something of an optimist, but I see only two problems: First, we will have to have a dual seed handling system. We are not going to have over-night change, so we must have systems to handle both regular cottonseed and glandless cottonseed. This won't require a lot of capital, but it is going to take some.

The second problem I see is more important and probably more expensive. That is the managerial problem of keeping the seed lots separate. In the particular company with which I am associated, we save a great deal of planting seed. We have found that it is an extremely difficult task to keep the different lots completely separate. The plant must be cleaned carefully between runs and this is time consuming. I see this as a problem, but the ginning industry is going through some changes which may help to solve this problem.

There is a current shift from the conventional system of bringing the cotton to the gins in trailers that carry about seven bales, to a modular unit system. This is a step in the right direction.

The number of cotton gins in the United States has been declining as dramatically as the dairies have been declining. I think the number will continue to decline and the remaining gins will be high-volume plants.

Large, high-volume plants will require better management. This, perhaps, will solve the managerial problem I mentioned.

I would say one more thing on a little broader scope, as a man who gets to Washington every now and then and is interested in politics and agricultural policy.

In moments like this -- and this is just a moment -- when we have about twice too much wheat and relatively depressed farm prices for all commodities, it is sometimes difficult to look ahead as we have done today and project the needs of the world.

But I think we all must look forward with the resolve to becoming better suppliers of economically priced food and fiber for our own people and for consumers of the world. I think it serves the best interest of the United States, the other dependent countries and each of us.

The Processor's Viewpoint

By C. Richard Rathbone

I am intrigued with this meeting and was glad it was put together. However, looking from the viewpoint of an oil mill you can look both ways--sitting in the middle and look both ways at these problems. I think Herv, you hit the nail on the head when you said there has to be an incentive. Somebody, and you Wilda pointed your finger at the oil mills. You thought they ought to get started. Well, somebody has to bite the bullet, that's for sure. Somebody has to, so to speak, put their money where their mouth is. I don't know who it's going to be because it is a complicated problem. Jack, you eluded to separate ginning, so to speak. I can't see it within one gin, but two gins perhaps would do it--isolation control, no contamination, and Hervey, I think you said the same thing--that you are picking and handling it separately right on through. The oil milling has the same problem and I don't think there is an oil mill in the country which could qualify for all the things that have been said here today on contamination, or the regulatory bodies, the FDA, the EPA, OSHA. Actually, in one way you come here to listen to all this and you feel like putting your tail between your legs and going home and saying "that's just too much to buck." But frankly, it has been a dream of mine and we have been working on it out in California and our good friend, Coop, is going to tell you more about it later on and I think we have come a long way. During this past year, when I was President of the NCPA, I had an occasion to visit with and attend other meetings of discussions of this nature and there is an enthusiasm there. It has to be done and somebody has got to do it. I don't know who it's going to be.

It was a great attempt in Lubbock on a different process but I have to give my personal opinion now that the particular process, in my opinion, was a great try to get it started for giving products to be tested in the market. When, unfortunately, mechanical problems prevented them from doing much. I understand that there is a study going on--it has been funded through an appropriation that is looking into this problem: what is the market, what are the mechanical problems--and perhaps from that study something will come to help us all out in our thinking if nothing else.

I was quite interested in the paper put out by the Texas A&M stating some facts and figures. Les Watkins eluded to the same thing and that was putting a few facts and cost figures down as to what it would do. Well, number one, it was indicated that we could produce better products less economically through certain

processing with less energy. Doing this we don't have to refine the oil as hard to get a better product and all of these things are really important. It also emphasized the feed values. I want to make this point because it might be an interim step. Feed values could be increased in their protein meal with the glandless seed. I think, Hal, you pointed that out--I think you made a statement of $9.00 a ton, perhaps. Going into these other markets that are not being used as of now--the pet foods, etc. you mentioned this morning. I know there is a potential in the poultry markets--poultry feeding because we had a reversal in California a year or two ago and the gossypol got a little high and we had to upgrade our tags and the poultrymen didn't like it--they cut down a little bit, they didn't use as much. But we've got some seed now that is lower in gossypol. We thank the Lord for Coop and the people out at Shafter that have been working on this and we are back in a little stronger in the poultry markets.

Well, there are a lot of problems--you talk about optimum conditions, but it is going to take, I think, the integration from the grower to the gin, of the oil mill and the food user and distributor, whether you can call it the food ingredient as mentioned or food additive and get the FDA approval. My question is and I would like somebody else to address to this, would that come from an individual or an oil mill to get this approval or would the group be willing to inaugurate this? Perhaps through the NCPA with a combined effort we have a great research committee and I think this could be done. Taking this Texas A&M study, and I don't think that Lusas went on to the final conclusion, that if you could sell protein, edible protein, and from his chart, if I remember correctly, a two-hundred ton mill for optimum returns and ten percent on the investment which is something like seven million, eight hundred thousand dollar plant that was added to his other statement, then I took 26¢ a pound. I don't know what this $2.40/lb. figure that was battered around here but that sounds intriguing. If we could ever get to that, it would be great. But just at those figures, I figured that the cottonseed is worth over $200 a ton. In the meantime, some of these other markets could increase its value, your oil return would be better. It is going to take a lot of doing and I don't know if there is a company today that is in the position to isolate the growing, the ginning, build another oil mill to the specifications of food grade plant and contract and give this incentive, Hervey, to the grower without the incentive coming from the food industry. Hopefully, from this Conference, that we in the oil mill business will be given a little more confidence and perhaps running with the ball. It's a pleasure to be here.

DISCUSSION

W. SMITH I would like a question of one of the gentlemen representing the food companies if they can answer it. Due to the nature of our business, my company's business, I attend meetings having to do with cottonseed

and also meetings having to do with peanuts and I hear papers given in both meetings having to do with cottonseed flour, also on peanut flour and I am curious if you can shed any light on what the relative merits are between the proposed peanut flour and the cottonseed flour, and what chance cottonseed flour might have to compete with that type of competition?

B. R. STILLINGS I think as pointed out by the three of us in industry, the main competition today for cottonseed is soy without question. That is firmly established in the marketplace. Peanut flour is available to some extent. We, as I am sure with most other food companies, are looking at all types of protein ingredients that are available. We have salesmen calling on us with peanut flour, and one of the points I made at the end regarding economics applies also to peanut flour. When salesmen start talking of .40 to .50 cents a pound for 50 to 60 percent protein flour from peanuts, we tell them to come back when they have something that has a clear advantage over some of the much lower cost protein flours that are available. Specifically, compared to peanut flour, cottonseed flour has some additional functional properties and is somewhat higher in protein quality. I am not familiar with the regulatory status, except that peanut flour must be considered on the GRAS list by FDA. Peanut flour has a problem because it is much more expensive than certainly soy, and certainly more expensive than the projected price that was given this morning for cottonseed. Peanut flour, however, is available and if a manufacturer wants to use it for its unique property in a particular product, he can start test markets.

M. D. WILDING Your question is very difficult to answer because you need to be very specific in terms of what product application you are dealing with. If it relates to the dairy system, obviously peanut has a clear color advantage. It is very compatible with the color of white dairy products. On the other hand, I would agree with Dr. Stillings that peanut is overpriced compared to other alternates that you can use. Flavorwise, it does not have any advantage because you have a strong peanut flavor. So, there are a lot of factors to consider in choosing a protein source material.

C. R. RATHBONE Can you give a range in price for cottonseed protein, a minimum and a maximum, at which you might say it would fit into varied use?

M. D. WILDING Obviously, the maximum price is casein. As long as casein is available and reasonably priced, the dairy industry is going to use casein or the milk system itself. If the price of casein increases, then a greater opportunity for protein alternates will occur. It has been stated that the protein alternate has to be 20 percent below the conventional protein before a strong advantage will exist for its use. Whether it be soy, peanut, cottonseed or anything else. Referring to Dr. Lugay's comments, it has to be comparable in use acceptance. People in the food industry are not going to put any kind of ingredient into a food just because it is cheaper unless it has a distinctive advantage. And those advantages would be nutrition, price, functionality, including flavor and other textural properties.

J. C. LUGAY I might just add from a consumer's standpoint that peanut has a decided advantage over cottonseed protein. The consumer has known and accepted peanut products over these last few years particularly, in the form of peanut butter, peanut brittle and peanut snacks. From the points-

of-view of a school child, he would readily recognize peanut brittle but if you tell him it is cottonseed brittle, he might not know what you are talking about. From that point-of-view, because peanut is well-known, it certainly has to have a decided advantage over cottonseed.

M. YUAN I would like to address my question to Dr. Lusas and the Texas A&M group. How would you assess the functional properties of glandless cottonseed proteins relative to those of soy proteins or peanut proteins, especially in terms of nutrition (PER) and certain functional properties such as emulsification capacity and stability.

E. LUSAS Actually, we have a major program on this at College Station. Peter, do you have anything that you can tell us about this now? It is a very comprehensive study, requiring about three years.

P. J. WAN This is a very important question which we would like to answer. However, at this point in time, it is difficult to give a summary to compare the functional properties of different vegetable proteins, but we do intend to accomplish this objective. Hopefully, by the end of the current research project, we can get a better picture about this subject.

F. H. HUSBANDS Mr. Cavanagh, let me ask a question. So far no one has commented on it but I might have missed it. I wonder if any of you gentlemen in your work have any ideas on the value of cottonseed protein as a substitute for casein in its industrial applications? My question is based on the fact that the quantity of casein is gradually declining and I know that Harold Wilcke at one time had some observations on the potential value of cottonseed protein as a substitute for casein in some industrial applications for which I understand there were no real valid synthetic substitutes in prospect.

H. L. WILCKE I am sorry. I have been retired too long to remember those.

NOT IDENTIFIED I cannot answer your question but I will venture some comments. Knowing the casein system very modestly, I think that most of your vegetable proteins do not have the necessary properties unless they are chemically or functionally modified in some way for use as sizing agents or other areas as glue, or adhesives and so forth. I think cottonseed, soy, peanut--no matter what it might be--would not have the properties as they exist now. But with some chemical modification, they could have that potential. However, I do not think anybody really knows the answer to that question.

M. J. LUKEFAHR You know in the rainbelt areas of cotton, where cottonseed is stored for long periods of time, the free fatty acids rise pretty fast from 3 to 5 percent. Now what would this do to the value of glandless seed to human nutrition when this free fatty acid became very high?

W. H. MARTINEZ Again, I think the answer will have to be that we do not exactly know. I alluded in my comments this morning to the fact that a major determinant of seed value would be oil yield. With high free fatty acids, you would have a high refining loss and, therefore, a lower recovery of oil. There always exists in this kind of situation the potential for creating off-flavors due to oxidation products from the fatty acids. This is not a statement of fact. This is simply a statement of a possibility which could exist under these circumstances.

M. J. LUKEFAHR Do you foresee there may be a need for special storage facilities?

W. H. MARTINEZ No, I don't really. All I think is that we need to put the present knowledge in practice.

M. J. LUKEFAHR O.K. Now under your solvent extraction process you use

hexane and hexane does not rupture the glands. Is this right?

W. H. MARTINEZ Yes, hexane will not rupture the glands. You must do the necessary rolling as Leslie Watkins pointed out, that is, the use of some physical means of rupture with or without moisture.

M. J. LUKEFAHR Now on the reversion process that has been alluded to several times. Early in the season from glanded varieties, you have a relatively clean, clear oil and, as the season progresses, you get a lot of coloration in the oil. This has been alluded to as gossypol-like compounds. How do these compounds get out of the glands into the oil in the solvent-extraction process?

W. H. MARTINEZ Gossypol does not exist in the gland in a free form. It exists as a complex which under conditions of time, temperature and moisture will form different pigments. I think with the age of the seed, you have changed both the toughness of the gland and the gossypol complexes and, therefore, their solubilities. You also have a change in the total permeability of the various cells of the seed and the extractability of the cell moisture and phospholipids. After cooking and flaking, what you are looking at with hexane extraction is the emulsification of water, phospholipids and gland contents which result in the pigmentation of oil.

M. J. LUKEFAHR Could these colorations be due to chlorogenic acid and/or the tanins or flavenoids?

W. H. MARTINEZ No, I think this has definitely been shown by research on the oil reversion and oil discoloration problems.

M. J. LUKEFAHR Now, I would like to ask Mr. Watkins a question. Earlier today, you indicated that you knew of some studies where the pigment glands are shown not to be defense mechanism against insects. Whose work did you have reference to?

L. R. WATKINS I do not recall the specific work. I do recall that at one time there was an insect infestation in the glandless field that was reported a little earlier than in adjacent fields. Later on, adjacent fields of glanded varieties came to have the same problem. The first thoughts were that the gossypol had been protecting the plant and that the glandless plant was without protection, therefore, it received much greater infestation. But a week later the adjacent crop had the same problem.

M. J. LUKEFAHR What area was this in?

L. R. WATKINS I think it was Arizona.

M. J. LUKEFAHR Did they treat both fields? Or did the infestation just go away without treatment?

L. R. WATKINS I don't remember. After the second advisory came along stating that the glanded field had the same problems, I think everything became equal and I did not hear any further.

M. J. LUKEFAHR You do not recall the insect?

L. R. WATKINS No, I do not.

L. R. WATKINS I would like to clarify a little bit about that gossypol and color reversion towards the end of the season. My feelings are that fresh seed has a certain moisture content and this moisture is divided into what I refer to as two different types. One moisture is surface moisture that is available to assist in rupturing the glands when the meats go to the rolls. Later on in the season after the cottonseed has dried, and this can be only two weeks time, not necessarily many months, this situation has changed. We have had some very practical experiences

with extra wet seed where we have set some aside and the processing of the set aside seed would have to be modified by adding water to assist in rupturing the gossypol glands. This change in processing operations can also be brought about by the drying that occurs in shifting seed from one cottonseed house to another cottonseed house. In one experience we had, a month old cottonseed that had been dried specifically to make it more millable. It had a color reversion problem until we added the additional moisture to compensate for the moisture that had been removed. I have seen situations where ten-and-a-half percent moisture was not enough and I have seen where six percent was enough. So percent moisture is not sufficient to determine how much moisture is necessary for the rupture of the gossypol glands. Once they are ruptured then they can be bound. But all the cooking and pre-press or hard-press is to no avail if you have not ruptured the glands prior to cooking. You will not get the gossypol bound and then, when you go through the expellers, you're going to have the gossypol in the oil extrudent.

S. P. SENGUPTA I have a question for Dr. Wilcke. He mentioned in comparing glanded and glandless cottonseed meal, that glandless cottonseed meal has more available lysine. Now we know that gossypol is a polyphenol compound and in our research with the wheat, we found that polyphenols are notorious binders of proteins; that is, the amino acids which are the building blocks of protein. We have found also that under adverse physiological conditions, like drought, the phenolic compounds bind more protein. As a result, the protein metabolism of the plant is starved and the plants die. Now the point is that if glandless cottonmeal should have more available lysine, I think that research should be conducted to find out whether they have more available amino acids like aspartic acid, lysine glutamic acid, etc. My question to Dr. Wilcke is whether any research has been done in that direction?

H. L. WILCKE I do not know of any and in fact, it's awfully hard to find any complete analyses on glandless. We do need this information, although some figures may be found in the recent National Science Foundation Report on research and food.

GENETIC BASIS AND BREEDING PROCEDURES FOR GLANDLESS SEEDED COTTON

By Philip A. Miller

All naturally occurring species of the cotton genus, Gossypium, are characterized by the presence of glands containing terpenoid aldehydes, including gossypol and related substances. In the seeds, the glands contain only gossypol. As has been documented in the previous session, gossypol may interfere with processing of certain seed products and detract from the value of the cottonseed to the producer and processor. It has long been recognized that a cotton with glandless seed free of gossypol would be of immense value to the cottonseed industry.

Genetic Basis

McMichael (1959) first reported the selection of strains of cotton with no glands in the seed and essentially zero gossypol content. He selected among plants of G. hirsutum race punctatum in a line known as "Hopi Monecopi," a primitive indigenous cultigen from the Hopi Indians of Arizona. With these selections he reduced the glands on leaves and bolls nearly to zero, although the seed were still glanded. However, when McMichael (1959) crossed Hopi Monecopi to cultivated strains of upland cotton, selections having glandless seed were found in the segregating populations. He examined the cotyledons of thousands of seedlings and selected for reduced number of cotyledonary glands over several generations until true-breeding glandless types were developed.

McMichael (1960) crossed these glandless types with various experimental strains and varieties of upland cotton. From a study of the segregating generations, he concluded that the glandless-seeded phenotype was controlled by two genes which he symbolized as gl_2 and gl_3. Roux (1960) used seed of the same lines to determine also that the inheritance was controlled by two loci.

Lee (1962) contributed additional understanding of the inheritance of glandless seed. He described the gland distribution patterns in the cotyledons of plants carrying various combinations of the active alleles Gl_2 and Gl_3. Later, Lee, Cockerham, and Smith (1968) recorded data indicating that in the upland cotton strains examined, Gl_2 produced about 2.5 times more gossypol in the seed than Gl_3. Lee (1962) also identified the existence of two additional loci that controlled the presence of glands in the cotyledons, but he concluded that alleles Gl_4 and Gl_5 were very rare in upland cotton and weak in expression.

Various other loci and alleles may control the distribution, size, and contents of glands in the seed and other parts of the cotton plant. McMichael (1954) described the effects of an allele designated gl_1, which removed the glands from the hypocotyl, stem petiole, and carpel walls. Another allele at this locus, designated Yuma glandless or Gl_1^y, eliminated only the smaller glands in the axial parts of the plant (McMichael 1970). Neither of these alleles altered the presence of glands in the seed, however, and did not

significantly affect seed quality. Barrow and Davis (1974) described an allele designated Gl_2^s (allelic to Gl_2), which gave a gland density in the cotyledons that was reduced relative to those from Gl_2 or Gl_3. Lee (1977b) described the effect of Gl_3^r, which may interact with an array of certain other gland-determining alleles at other loci to produce rugate fruit surface. The rugate characteristic appears to be associated with increased terpenoid aldehyde levels in the flower buds. Lee (1977a) also presented evidence that, in addition to Gl_2 and Gl_3, various modifying genes altered the amounts of gossypol stored in the seed. Quantitative variations in the total gossypol content of different normally glanded varieties have been observed by several researchers (Pons, Hoffpauir, and Hopper, 1953; U.S. Dept. of Agric. and the California Agricultural Experiment Station, 1977). Bell and Stipanovic (1977) reported that the terpenoids varied chemically within glands in the flower buds and vegetative organs of the plant, and they presented preliminary data suggesting that these variations were under genetic control.

Gossypium bickii and *G. australe*, diploid species of wild cotton native to Australia, are unusual in that glands are not formed in the cotyledons until after the seed germinate (Fryxell, 1965). Thus the seed are glandless, but the expanded cotyledons and vegetative plant parts are glanded. Because these species are only very distantly related to our cultivated cottons, the likelihood of successful transfer of this characteristic into adapted cultivars seems remote and, at best, many plant generations of selection and breeding would be required.

Thus, within upland breeding material glandless-seeded cottons can apparently be obtained by selecting for the proper alleles at only two loci. Seed from plants that are homozygous gl_2 gl_2 gl_3 gl_3 are essentially free of gossypol and related substances.

Breeding

Because gl_2 and gl_3 were discovered in the progeny of a cross between Hopi Monecopi and an Acala variety, the first true-breeding strains with glandless seed had many of the undesirable features of the primitive Hopi cotton, including low yield, poor fiber quality, and a general lack of adaptation to modern cultural practices. Breeders were challenged to develop a glandless-seeded cotton equal or superior to the glanded commercial varieties in yield, fiber quality, and other economic traits. A backcross breeding scheme appeared to be the most appropriate for accomplishing this objective. Under this breeding procedure, a commercial variety was crossed with a glandless-seeded experimental strain, and the progeny were repeatedly backcrossed to the commercial variety with selection in each generation to insure the retention of the gl_2 and gl_3 alleles.

In theory, four to six backcrosses followed by selfing would be required to recover a true-breeding gossypol-free strain with yield, fiber, and other performance characteristics approximating those of the original cultivar. This backcrossing scheme did, in fact, become the most widely practiced procedure in glandless breeding programs (Hosfield, Lee, and Rawlings, 1970; Hyer, 1966; Lewis, McMichael, and Lee, 1962; Meyer and McCrory, 1962; Miravalle and Hyer, 1962).

As the backcross breeding programs progressed, however, it became apparent that when the glandless genes were transferred from the original experimental lines, other genetic material that reduced yield and adaptation was also

transferred. Associations of these adverse effects with gl_2 and gl_3 were reported by several investigators (Hosfield, Lee, and Rawlings, 1970; Kohel, 1974; Lee, 1967). Although their experiments were not designed to distinguish between genetic linkage and the direct effect of the glandless alleles themselves, the pattern of results suggested that linked factors were probably the major cause of the loss of performance. Undesirable linkage associations can be overcome in breeding programs, but it does require additional generations of crossing and selfing, the growing of larger populations in each generation, and a more extensive testing and evaluation program. Thus the presence of linkage effects significantly increased the time and effort required to reach the objective of commercially acceptable glandless cottons.

In addition, breeders using the backcross breeding approach often find themselves "shooting at a moving target." For example, a breeder may start a program to convert glanded variety "A" to a glandless-seeded type. Although the program may proceed successfully and on schedule, he may find that after reaching his objective the original variety has been replaced by a superior variety "B". Thus, he is always playing "catchup" and is never quite successful in developing a gossypol-free variety equal in performance to the best available glanded type. This is especially likely when undesirable associated effects increase the number of generations required to recover the recurrent parent variety.

Breeders have long recognized the inherent weaknesses of backcrossing as the sole breeding approach (Barker, 1962; Miravalle, 1968). Consequently, as glandless strains approach commercial varieties in performance, the better recovered glandless lines may be intercrossed. When two or more gossypol-free strains are intercrossed, all of the segregating progeny are glandless and the breeder can concentrate on selecting for yield, fiber quality, pest resistance, and other performance characteristics within the stable glandless background. During the past 15 years breeders have recovered a large number of glandless strains from a range of varietal backgrounds, and intercrossing among these types is providing new and improved material for selection and evaluation.

Perhaps we were overly optimistic in 1959 when McMichael first reported the discovery of cotton with glandless seed, and we assumed that within a few years we could convert our entire crop into gossypol-free types. We have, however, developed some glandless strains with excellent performance and further improvement is anticipated. The next presentation on our program is a report from a panel of breeders on the development, performance, and availability of glandless-seeded varieties for the different production zones across the Cotton Belt.

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GLANDLESS COTTON BREEDING IN THE FAR WEST: A PROGRESS REPORT

By Hubert B. Cooper, Jr. and A. H. Hyer

This is a summary of the research and thoughts or views on breeding for glandless cotton of researchers in the Far West. Those involved are Dr. Carl Feaster and Dr. Ed Turcotte, ARS Pima breeding program in Arizona; Dr. Norman Malm and Mr. Carl Roberts, New Mexico State University, Upland breeding program; and Dr. Hubert B. Cooper and Dr. A. H. Hyer, ARS Upland breeding program in the San Joaquin Valley of California. Mr. Elmer Gilbert, in charge of the Upland breeding program in Arizona of Delta and Pine Land Company, reported that they were doing glandless breeding work in Lubbock. Progress of those breeders, as well as ours, in breeding for yield potential, fiber quality and insect and disease tolerance will be discussed.

Dr. Feaster and Dr. Turcotte reported that, in the Pima cotton breeding program, the transfer of the glandless character from Shafter Gl 38-6 into Pima background began in 1958. The backcross system was used and Pima S-1, S-2, S-4 and S-5 were the succeeding recurrent parents through eleven backcrosses. The fiber qualities of Pima S-5 have been reestablished in the glandless genotypes. No yield comparisons have been made, but the glandless material appears to be about 10-20% less productive and later maturing than Pima S-5.

Dr. Malm and Carl Roberts reported that the glandless breeding material was very susceptible to Verticillium wilt when they started their breeding work. They have, in the last few years, developed glandless lines with high levels of tolerance to Verticillium wilt. They readily transferred good fiber qualities into the glandless strains. Length and strength were similar in their glandless strains to Acala 1517-75 (Tables 1 through 3). The yields of the better glandless strains were consistently lower than those of the Acala 1517 varieties. Yields of glandless strains have not equalled those of the Acala 1517 varieties, partly because the glandless breeding program has lagged behind the main breeding program. However, in 1977 the yield of two glandless cottons yielded about the same as Acala 1517-75 at the Las Cruces location (Table 4), whereas the yield of Acala 1517-75 exceeded that of the glandless strains at Artesia, N. M. (Table 5). These researchers reported that the glandless strains matured slightly later than the bulk of the New Mexico breeding material. They developed early maturing strains but yields were greatly reduced.

Dr. Hyer developed the glandless breeding program in California. He used the backcross method for transferring the glandless genes into the Acala background. His work led to development of G8160, which has essentially the same genetic background as Acala SJ-2, by backcrossing to Acala SJ-1.

Because of the apparent success of G8160, we decided to change the emphasis of our breeding effort by transferring the glandless breeding program to the applied breeding program of Dr. Cooper. We split our effort in the applied breeding program. Approximately 60% and 40% of our effort is devoted to

(Continued on page 87.)

TABLE 1.--Yield and fiber quality of one glanded and three glandless cottons at Las Cruces, N.M. in 1976

Strain or Variety	Yield in lbs. lint/A	2.5% Span length-inches	T_1- Fiber strength g/grex
Acala 1517-75	1418	1.23	22.7
G 1222*	1189	1.26	23.6
G 1301*	1168	1.21	22.1
G 1261*	1103	1.23	22.3
L.S.D. .5%	175	0.03	0.4

*Glandless

TABLE 2.--Yield and fiber quality of three glanded and two glandless cottons at Las Cruces, N.M. in 1976

Variety or strain	Yield in lbs lint/A	2.5% Span length-inches	T_1- Fiber strength g/grex
Acala 1517-75	1271	1.24	21.5
Acala 1517-77	1178	1.24	21.7
Acala 1517V	1126	1.24	20.6
G 866*	987	1.21	20.3
G 838*	980	1.24	20.9
L.S.D. 5%	91	0.04	1.1

*Glandless

TABLE 3.--Yield and fiber quality traits of three glanded cottons compared to two glandless cottons at Artesia, N.M. in 1976

Variety or strain	Yield in lbs lint/A	2.5% Span length-inches	T_1- Fiber strength g/grex
Acala 1517-77	971	1.18	23.8
Acala 1517E-1	920	1.18	22.8
Acala 1517-75	907	1.21	22.7
G 838	883	1.17	22.2
G 866	844	1.19	21.0
L.S.D. 5%	121	0.03	1.0

TABLE 4.--Yields of one glanded and three glandless cottons at Las Cruces, N.M. in 1977

Variety or strain	Yield Lbs Lint/A
G 838	1281
Acala 1517-75	1269
G 1767*	1261
G 1222*	1088

*Glandless

TABLE 5.--Yields of one glanded and three glandless cottons at Artesia, N.M. in 1977

Variety or strain	Yield in lbs lint/A
Acala 1517-75	1208
G 1767*	1022
G 1222*	937
G 838 *	931

*Glandless

glanded and glandless breeding, respectively. We have the glandless genes in several genetic backgrounds so we have moved away from the straight backcross procedure. We are, for the most part, using intercrosses between different glandless lines. We feel that our progress will be faster using this procedure.

Because G8160 performed as well as Acala SJ-2 under insect free conditions and because of the interest of the crushing industry in glandless cotton, we decided to test G8160 in large plots and over a wide range of conditions. The primary objective was to determine if it could be commercially grown. We tested G8160 in five large test plots in 1974. The plot size was 4, 6, or 8 rows, one-eighth to one-half mile long, replicated four times. The results of these tests are shown in Table 6. There was no evidence of lygus damage in three of these tests in which the yield of G8160 was 98 and 99% of that of Acala SJ-2. In two of the tests the yields of G8160 were 86 and 74% of that of Acala SJ-2 and damage by lygus was moderate. We had observed lygus damage in small scale test plots prior to 1974 and knew that glandless cottons were more susceptible. We reasoned that lygus damage might be magnified in small plot tests; however, results from the larger test plots suggested that the potential for lygus damage still existed.

We tested G8160 again in our 1975 advanced strain tests (Table 7). Light lygus damage was observed in six of the tests and the yields of G8160 ranged from 95 to 104% of that of Acala SJ-2. In the remaining three tests lygus injury was moderate to severe and the yields of G8160 ranged from 91 to 63% of that of Acala SJ-2. The 37% reduction was caused, in part, by damage from weeder geese early in the growing season.

We also compared yields of G8160 and Acala SJ-2 in 8-to 9-acre plots replicated four times at four locations to remove the bias of border rows and to better evaluate insect damage (Table 8). There was no evidence of lygus damage at Corcoran and only light damage at the other three locations. The yield of glandless at Five Points was 17% lower than that of glanded. The reason for this reduction was not clear. The seed quality traits of Acala SJ-2, SJ-4 and G8160 are in Table 9.

Based on these data growing large acreages of G8160 instead of glanded cottons would reduce average yields by about 10% in years with normal insect populations. Decreases in yield would be even greater in years with higher than normal insect levels. We reviewed these results with representatives of industry and concluded that the risk of loss from insect damage was too great to attempt to grow large acreages of G8160 for experimental crushing. We decided, instead, to intensify our breeding work and to attempt to develop a glandless cotton that would be an improvement over G8160.

G8160 and Acala SJ-2 have about the same level of tolerance to Verticillium wilt. This level is not adequate for cultivation of the plants on approximately 30% of the acreage of the San Joaquin Valley. G8160 is also a tall growing plant we were able to select for plants that were shorter and more determinant than G8160 and that had greater wilt tolerance. The yields of some of our recent selections are summarized in Table 10. Wilt tolerance of three of the glanded cottons was considerably improved as shown by their performance under conditions of severe wilt. There are no direct comparisons with G8160 in this experiment but its yield is similar to that of Acala SJ-2. Insects were not a problem at either location.

In the second year of evaluation (Table 11), we directly compared our selections with G8160. Wilt was severe at Strathmore and the yields of Acala

(Continued on page 91.)

TABLE 6.--The yield and fiber quality of two varieties and one glandless strain of cotton in 1975*

Variety or strain	Yield in lbs lint/A	Fiber Quality Traits: 2.5% Span length-inches	micronaire	Yarn tenacity
Acala SJ-2	1100	1.11	4.22	13.5
Acala SJ-4	1093	1.11	4.02	14.5
G 8160 **	991	1.11	4.15	13.6
L.S.D. 5%			0.16	0.3
C. V.		1.17	2.91	1.86

*Means of five tests grown in the San Joaquin Valley of California
**Glandless

TABLE 7.--The yield and fiber quality of two varieties and one glandless strain of cotton in 1975*

Variety or strain	Yield in lbs lint/A	Fiber Quality Traits: 2.5% Span length-inches	micronaire	Yarn tenacity
Acala SJ-2	1111	1.11	3.48	13.6
Acala SJ-4	1167	1.11	3.64	14.6
G8160**	1008	1.12	3.60	13.5
L.S.D. 5%			0.06	0.2
C.V.		1.59	3.70	2.10

*Means of nine tests grown in the San Joaquin Valley of California
**Glandless

TABLE 8.--Comparison of the yields of one glanded and one glandless cotton grown in large scale test plots in 1975*

Variety or strain	Yields in lbs lint/A				Average Yield in lbs lint/A
	Corcoran	Bakersfield	Visalia	Five Points	
Acala SJ-2	1152	1230	1294	1588	1316
G8160**	1128	1098	1322	1321	1217
L.S.D. 5%					
C.V.					6.9

*Means of four tests grown in the San Joaquin Valley of California. Eight to nine acre plots.

**Glandless

TABLE 9.--Seed quality of two glanded and one glandless cotton in 1975*

Variety or strain	Linters %	Oil %	NH_3 %	Gossypol %
Acala SJ-2	12.99	17.96	3.99	1.25
Acala SJ-4	8.86	20.85	4.28	0.93
G8160**	13.65	18.65	4.04	0.04
L.S.D. 5%	0.67	0.93	0.13	0.09
C. V.	4.16	3.65	4.21	7.31

*Means of eight tests grown in the San Joaquin Valley of California

**Glandless

TABLE 10.--The yields of two glanded and four glandless cottons in 1976

Variety or strain	Yield in lint lbs/A by location*		Average Fiber Quality Traits		
	Shafter	Strathmore	2.5% Span length-inches	Micronaire	T_1- Fiber strength g/grex
Acala SJ-2	1231	785	1.13	3.04	21.2
Acala SJ-4	1368	1210	1.13	3.58	22.8
G 4611**	1420	1401	1.12	3.68	21.3
G 4612**	1197	1417	1.15	3.72	22.3
G 4663***	1185	723	1.14	3.10	23.4
G 4684**	1336	1350	1.13	3.77	21.3

*Light to moderate wilt at Shafter and severe wilt at Strathmore
**Wilt tolerant glandless cottons
***Low wilt tolerance glandless cottons

TABLE 11.--The yield of two glanded and four glandless cottons in 1977

Cotton	Location and Yield in lbs lint/A				
	Kern Lake	Shafter	Strathmore	Visalia	Over Loc
Acala SJ-2	1136	1208	1023	1130	1124
Acala SJ-5	1206	1357	1235	1186	1246
G 4611*	1184	1413	1400	1095	1273
G 4612*	1184	1270	1328	1099	1220
G 4684*	1076	1207	1326	1009	1155
G 8160*	1169	1223	1070	1043	1126
C. V.	5.32	9.66	8.99	9.75	8.4
L.S.D.	93	186	168	144	124

*Glandless

SJ-2 and G8160 were similar and greatly reduced compared to yields of the other glanded and glandless cottons. A worm problem existed at the Visalia location as well as a moderate wilt infestation, and yields of the glandless cottons were reduced.

The results with some of our new glandless strains are shown in slide 12. The results will not be published since yield is in pounds of seed cotton per acre and represents only one location in 1977. Some of these cottons appear promising, but they must be evaluated for two to three more years. In most of these strains, yields and lint % were improved and length, strength, and fineness of fibers were satisfactory when compared to Acalas SJ-2 and SJ-4.

Breeding work in Shafter and New Mexico has shown that we can develop high yielding, wilt tolerant and early maturing glandless cottons with satisfactory fiber traits. Susceptibility to insects and rodents appears to be the real problem with glandless cottons. The New Mexico researchers have results from feeding trials that show greater bollworm weight on glandless than on glanded cottons. We found that the growth rate and survival of lygus nymphs was greatest on glandless cottons. All data to date shows that lygus and bollworms reduce the yield of glandless cotton as compared to glanded cotton. The years during which tests were conducted in California were minimal insect problem years, except for some spotty outbreaks. We do not know how these cottons would perform under severe lygus and bollworm outbreaks. We found that lygus reproductivity varied with different glandless lines, which suggested genetic differences in the lines. The New Mexico researchers have results which indicate that tannins in both glanded and glandless cottons are more important in controlling insect resistance than gossypol. One of their objectives is to breed for high levels of tannins in the plant terminals. We do not have a reliable way of screening for insect resistance in the absence of a natural population.

Rodents are another problem. Dr. Feaster and Dr. Turcotte encountered problems with rodents in both the greenhouse and the field. Mice in the greenhouse frequently ate the glandless seed at planting. Rabbits in the field on occassion destroyed their glandless plants after emergence. Rabbits, squirrels, pheasants, and, in one case, weeder geese have damaged our field plantings. Field mice and squirrels have also damaged our mature bolls in the field. We do not know how severe this problem would be in the agronomic production of glandless cotton. However, mice and rats could be a serious problem during prolonged storage of glandless seed.

The researchers had the following comments concerning glandless releases and agronomic production. Dr. Feaster and Dr. Turcotte do not expect to release commercially a glandless Pima cotton until Upland cotton grown in the Pima production area is glandless. Pima and Upland cottonseed are processed together, so there is little or no advantage to producing glandless Pima seed when the bulk of seed produced in the area is glanded Upland. Dr. Malm and Mr. Roberts felt that some growers in the Mesilla Valley of New Mexico might agree to grow glandless seed under contract if a sufficient premium were paid. We could not produce a commercial release in California for three to five years. It would take us that long to establish yield performance, assess our insect management program, and to increase the seed. If we successfully developed a glandless cotton with equal or greater yield, wilt tolerance, earliness and fiber quality traits and that could be cultivated with no increase in pesticide costs, as compared to presently grown glanded cottons, it would be released in California. If glandless cottons, however, had

deficiencies that would not be solved by breeding, such as insect susceptibility, then a premium price might have to be paid for the seed crop to encourage production.

DEVELOPMENT, PERFORMANCE AND AVAILABILITY OF GLANDLESS SEED COTTON VARIETIES IN THE SOUTHWEST STRIPPER HARVEST AREA

By Levon L. Ray

HISTORY OF VARIETY DEVELOPMENT

Following McMichael's isolation of the gl_2gl_3 genes in the late 1950's, many breeders became involved in transferring these genes to potentially commercial cottons. Breeders of varieties for the stripper harvest areas were the first to market glandless cotton varieties. In the mid-1960's, the Gregg Seed Farms was marketing a glandless variety, Gregg 25V (1). This was followed in the late 1960's by the Watson glandless varieties marketed by Rogers Seed and Delinting Company and in the early 1970's by glandless varieties released by J. H. Lambright. In the last two years glandless varieties have been released by two other companies, giving High Plains producers a choice of several glandless varieties.

Since 1965 cotton growers in the Texas High Plains have been planting from 10,000 to perhaps as much as 50,000 acres each year to glandless varieties. For the most part, these plantings have been made without any premiums on the cottonseed price; and most of the seed from these plantings have went into the normal cottonseed processing channels losing the advantage of the low gossypol character of the glandless varieties.

PERFORMANCE OF GLANDLESS VARIETIES

Commercial glandless varieties have been tested by the Texas Agricultural Experiment Station at Lubbock since 1965. In the first several years they were tested in performance trials along with the standard glanded varieties, usually only one to three glandless varieties and 20 to 30 glanded varieties. Yields of the glandless varieties were generally disappointing (Figure 1), seemingly much lower than that experienced by growers. It was possible that the preponderance of glanded varieties caused a concentration of insects in the glandless plots thereby reducing their yield. For this reason a testing program was begun in 1973 where all but two of the varieties were glandless. The comparative yield performance of Gregg 35W with the glanded checks, Tamcot 788 and Paymaster 111A, was similar in these tests to results from the standard variety test, except for 1975 (Figure 1). In this year the relative yield of Gregg 35W was significantly lower in the standard tests. The relative low yields in the early years of testing in the standard variety may have been due to insect pressures or possible heritable changes in yielding potential of the glandless variety.

Results of the glandless cotton variety tests at Lubbock are shown in Table 1. More complete information is available in MP-1338 (2).

The following conclusions have been drawn from our research at the Lubbock Center.

(Continued on page 96.)

Figure 1. Comparison of yields of glandless varieties, Gregg 25V (1965-1971) and Gregg 35W (1972-1976) with the average yield of Tamcot 788 and Paymaster 111A in the standard variety tests and in special glandless variety tests at Lubbock.

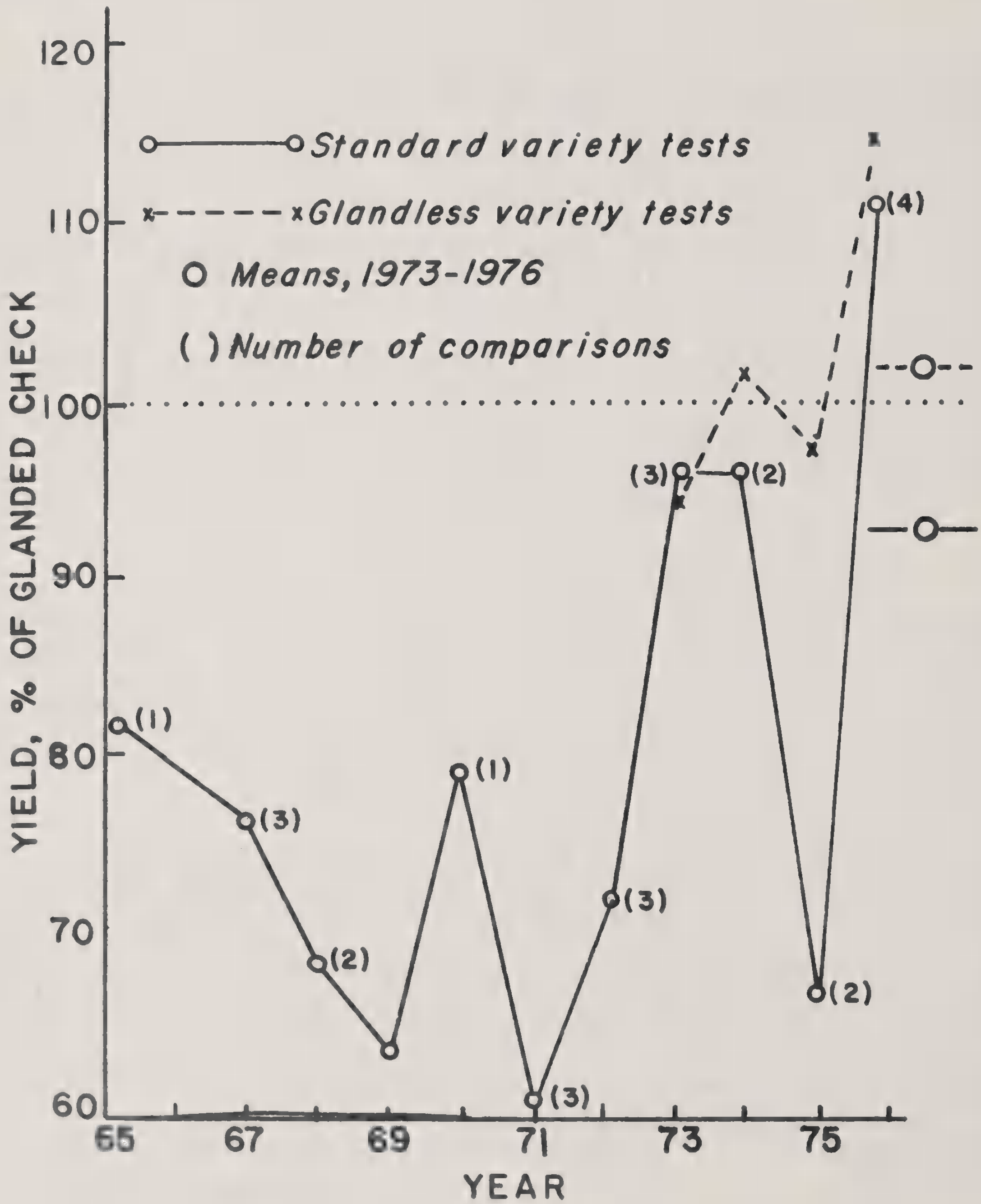

TABLE 1. Performance of glandless cotton varieties at Lubbock, Texas, 1973-1976

Variety	Yield, pounds per acre		Fiber properties		
	Lint	Seed	Length 2.5% span	Micro-naire	Strength, PSI
			Glandless Varieties		
Paymaster 784[1/]	589	999	0.93	3.4	80.9
Lyman	540	974	1.00	3.2	82.3
Gregg 35W	536	968	1.03	3.5	90.0
GSA 71017	525	984	0.96	3.7	91.1
Lockett 22	504	930	1.01	3.3	83.7
Lambright Gl-4	472	789	1.00	2.9	84.6
			Glanded Check Varieties		
Tamcot 788	588	1044	1.03	3.2	91.1
Paymaster 111A[2/]	484	887	1.01	3.2	86.1

1/ Tested as Paymaster 464

2/ Not grown in 1976; three-year means adjusted to provide comparable data.

Lint Yields

The average per acre lint yield of the two glanded checks varied by approximately 100 pounds of lint per acre and the six glandless varieties included in all four years fell within approximately the same yield range (Table 1). One glandless variety had an almost identical yield of the highest yielding check, Tamcot 788, and the yield of only one glandless variety fell below that of the lowest yielding check variety and this by only 12 pound per acre.

Seed Yield

Seed yields generally paralleled lint yields. However, there were some exceptions. For example, GSA 71017 produced 11% less lint than Paymaster 785 but only 1.5% less seed. Some experiment varieties which were not tested all four years had even higher seed/lint ratios.

Fiber Properties

Most of the glandless varieties were characterized by shorter, but coarser, fiber than the two checks (Table 1). Fiber strength was quite variable, but two varieties has essentially the same fiber strength as Tamcot 788 which has a relatively strong fiber.

Disease Resistance

Some glandless varieties have been evaluated under severe verticillium wilt conditions. Although none of the commercially available glandless varieties, several have a much higher level than many of the commonly grown varieties. Some experimental glandless lines tested have shown resistance as high as that of any commercial glanded variety.

Resistance to bacterial blight varies among glandless varieties, some are highly susceptible but others are highly resistant to prevalent races.

Insect Problems

The Texas High Plains has been relatively free of insect problems in cotton. For this reason, there is a general feeling that this area could grow glandless varieties more successfully than most other areas.

None of the glandless variety trials were sprayed for insect control and no significant infestation of damaging insects was observed.

Also, grower experiences have not indicated any unusual insect problem in glandless cotton. A few second hand reports have been received of severe insect problems in fields of glandless varieties but these have not been confirmed.

Dr. Don Rummel, research entomologist with the Texas Agricultural Experiment Station at Lubbock, has completed a three-year study comparing insect infestations and damage in glandless and glanded varieties grown on a farm-production scale. No unusual insect problems were encountered in the glandless varieties. In 1975, the glandless cotton did have a higher bollworm infestation, but from a practical standpoint he did not see this as a problem in growing glandless varieties. In one year higher aphid infestations were noted in the glanded varieties.

Herbicide Damage

Research has shown that glandless varieties are more susceptible than glanded varieties to certain herbicides (3). Especially striking is the reaction to an experimental herbicide, fluridone. However, the glandless varieties have not shown any unusual susceptibility to the commonly used preplant incorporated herbicides. Although the situation dictates that certain cautions are observed in using herbicides, the problem certainly does not negate the growing of these varieties.

FUTURE PROSPECTS

Most breeders of stripper harvested varieties have a glandless program. Some experimental glandless lines which have been tested only one or two years have shown outstanding performance. Considering the number of years the glandless genes have been available to breeders continued improvement would be expected.

Glandless varieties are now available which will compete with glanded varieties and which can be successfully grown on the Texas High Plains.

REFERENCES AND NOTES

1. Mention of a trademark or a proprietary product does not constitute a guarantee or a warranty of the product by The Texas Agricultural Experiment Station or The Texas Agricultural Extension Service, and does not imply its approval to the exclusion of other products that also may be suitable.

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DEVELOPMENT, PERFORMANCE AND AVAILABILITY OF GLANDLESS SEED VARIETIES IN THE MISSISSIPPI VALLEY

By Wolfgang H. Wessling

The development of glandless cotton breeding material is concentrated in five out of twelve cotton breeding programs in the Mississippi and Red River Valleys. The largest program is that in Louisiana with extensive testing at several stations in the Louisiana state experiment station system.

In all breeding programs, yield and earliness were indicated as principle aims. The two programs in Louisiana, in Baton Rouge and at the Red River Valley experiment station, emphasize fiber properties besides seed quality. High fiber strength, optimum micronaire, fiber uniformity and length are goals.

Emphasis is placed in all glandless breeding programs on insect and disease resistance. Heliothis spp., Fusarium Wilt and nemotodes are the main targets. In the case of the Missouri program, the multiple disease resistance approach is taken.

Smooth-nectariless combinations are incorporated in most programs.

While the Arkansas Experiment Station released 'Glandless Rex' as a variety more than ten years ago, the present program is in its early stages. 'Glandless Rex' was used as a source of seed research and has, according to recent variety tests, a competitive yield potential with leading local varieties.

The Stoneville Pedigreed Seed Company program is aimed to develop material that readily competes with their leading varieties. Their research effort in this area goes back to material that was developed by the late Dr. Jim Meyer. One of the best strains in the seed company's program showed initially very promising yield and fiber properties very similar to Stoneville 213. It proved, however, in later years more susceptible to environmental changes and insect attack that reduced the yield.

A total of several thousand glandless progenies are grown and improvements are measured in strains tests at various locations. However, very few strains have reached variety tests.

Other cotton breeders in the private sector did not indicate interest in the development of glandless varieties for the Mississippi Valley and adjacent areas under present circumstances. The question of oil mill demand for glandless seed and the lack of rapid testing methods to determine protein and oil quality are listed as the main reasons for lack of interest. Some of the cotton breeders in the public sector consider breeding of glandless cottons to various degrees. Screening for insect resistance factors and their detection are part of this effort.

DEVELOPMENT, PERFORMANCE AND AVAILABILITY OF GLANDLESS VARIETIES IN THE SOUTHEAST

By James L. Helm

The Southeastern United States has two major commercial glandless breeding programs. Also, Cotton Incorporated has a program and there are several minor public programs at various State and Federal stations in the area. For the most part, the minor programs use the glandless trait as a genetic tool and may also think of it as a desirable trait for the future. Thus, they carry it along in their stocks and in some cases have it in germplasm pools. These may be pools maintained for some time or recent pools synthesized for future development. I would estimate that among the public programs in the Southeast, glandless breeding consumes less than five percent of all breeding time and resources. Combined, these institutions would have less than 2,000 nursery rows, no glandless yield tests, and to date, no glandless varieties ready for seed increase and release.

The program at Cotton Incorporated, Raleigh, North Carolina is somewhat larger than any of the public programs, with a few hundred nursery rows--no glandless yield tests and only germplasm available to other breeders at this time.

The two major commercial breeding programs are at McNair Seed Company, Laurinburg, North Carolina and Coker Pedigreed Seed Company, Hartsville, South Carolina. These commercial firms have had breeding programs since the 1950's--depending on the year, something in excess of a couple thousand nursery rows each, for the past ten years. Each firm has extensive yield testing programs for glandless varieties. Both firms have varieties ready for release that are equal to glanded varieties presently grown and adapted to the growing conditions of the Southeast. By "equal to", I mean not statistically significantly different from, for lint yield per acre and the fiber properties - length, strength, fineness, uniformity and color.

Coker Pedigreed Seed Company has two glandless varieties, one glabrous, one pubescent, at the stage of advanced seed increase and ready for release. The glabrous variety has been named Coker 711. Coker also has several additional experimental lines at various stages of seed increase and many in its yield testing program.

McNair Seed Company has three advanced experimental varieties in a seed increase program and ready for release. One of the McNair varieties is large seeded and produces large meats of uniform size and conformation when hulled. This may be very desirable for certain food uses. They also have many additional experimental varieties at various stages of seed increase and many in their yield testing program.

Neither McNair Seed Company nor Coker Pedigreed Seed Company feel glandless varieties should be released in the Southeast without encouragement and direction from the oil mill and related food industries. They await that direction.

DISCUSSION OF PAPERS ON BREEDING

C. R. RATHBONE From an oil mill standpoint, any reduction in gossypol through plant breeding and selection would be beneficial.

P. A. MILLER I think that is a point which needs to be emphasized. Certainly, the goal of complete absence of glands (gossypol free) would be more desirable, but any reduction of seed gossypol can be beneficial to the crushing industry. H. B. Cooper at Shafter has demonstrated that this is feasible. His recent Acala releases have reduced seed gossypol as compared with the earlier material.

M. J. LUKEFAHR I would like to ask Dr. Levon Ray what happened to the seed on this 20-50,000 acres of glandless cotton grown on the High Plains of Texas and how was that utilized?

L. L. RAY I would like to remark about this acreage, which is not a large percentage of our acreage but does produce a significant tonnage of seed. This production has been for the most part grown without any price incentive. In other words, growers have chosen these varieties in competition with glanded types and the seed has gone into normal channels and in general no advantage has been taken of any added value of the glanded seed. However, Rogers Seed Company has utilized the glanded seed character in some of their production. They may want to address this.

W. SMITH I would like to ask Mr. Helm a question with reference to glandless varieties in the Southeast. Most of the oil millers in the area know of the problem of severe losses taken on oil quality on the cottonseed raised in that area now (glanded varieties I am talking about) and we attribute this, either rightly or wrongly, to a fragile seed coat. I am wondering, will you comment on the seed coat on the glandless varieties that you are working on, and also any comments you might want to make on how improvement in the oil quality might be produced which could serve the mills in the Southeast as an economic incentive to encourage glandless varieties.

J. L. HELM In relation to oil quality, the numbers that we have gotten back of oils from glandless cottonseed have been higher values in oil quality than we have ever seen for any glanded oils that come through the mills in the Carolinas. In relation to the seed coat situation, we have both types of seed coats in our program. We have some that are historically poorer, that is they break, they are brittle, they crack, this sort of thing. We have some in the program that are fairly thick and hold up pretty well. Henry Webb might want to comment in relation to the program at Cokers, but I would guess that he has both in his program as well.

H. W. WEBB I think you've covered it quite well, Jim. We do have some encouraging material from the standpoint of gossypol reduction. We have also observed some significant or, I think very meaningful, increases in both oil and protein in some of our glandless lines. From the standpoint of seed quality, or fragile seed coats, historically this has been a problem in the Southeast. I do not know how much is varietal and how

much is environmental. I am sure it is some of both. We are devoting quite a bit of effort to improving seed coat characteristics from the standpoint of toughness of seed coats or the ability to withstand ginning damages, handling, etc.

Generally speaking Jim Helm has represented our position in glandless breeding and the fragile seed coat problem.

I would like to pursue one point that was brought out a moment ago, and that is, what are the potential contributions of these intermediate levels of gossypol that we have been talking about, for example, H. B. Cooper's SJ-4 and SJ-5 are roughly down to 9/10 of one percent and the crushers are expressing considerable interest in this, are they not?

H. B. COOPER Yes they are, and I would like to refer that question back to Mr. Rathbone or George Cavanagh here to make some comment concerning what this means to them.

C. R. RATHBONE Well we started pushing for this many years back and Cooper finally came through. As you know, we have a situation on the West Coast wherein quite a poultry market was developed, poultry feed, wherein we were able to guarantee free gossypol levels and something happened and the gossypol got up a little bit too high and the poultry men became a little bit reluctant to pay those prices that we had. You understand that area competes with soybean meal shipped in from the Midwest and the differential freight of $35 to $40 a ton. Thus, we had a ceiling there to which we could take advantage. So, when this happened we had to raise our guarantees and our tags from .04 to .06. They didn't like it, they thought they couldn't use as much and we lost those markets and price-wise too. With the advent of some of this lower gossypol seed we were able to to back to our guarantees hopefully then starting to regain some of those markets, and it means quite a bit financially.

P. A. MILLER We have stable genetic lines with .3 to .4 percent gossypol. Would this reduced level of gossypol be even more advantageous to the seed crushing industry than the .9 percent that we had been discussing?

C. R. RATHBONE Yes, any reduction as I said early would be beneficial. It is not only beneficial from the standpoint of production of the meal but also for the oil. We have found that gossypol varies across the Cotton Belt. We have found seed that ran as high as 1.75% gossypol, and this was in the Southeast where there was considerable weather damage to the seed, both in the field and in storage. I think most of the color problems are in the gossypol gland and I think Wilda was talking about the permeability of the seed and what happens to gossypol under conditions of high moisture storage. Then you get reversion before you even get a chance to process it. So I am certain that any percentage reduction is going to benefit this condition all the way through, not just in processing, but also before it ever gets to the oil mill. So let us look at it that way too. Lower gossypol will benefit both the oil and the meal.

J. FOSTER Picking up on what Mr. Rathbone said, I wonder if all of us here went out and planted glandless seed, how many acres we would control? We are not really talking about the mainline person, the farmer who is out there planting it. We are here convincing each other it is a good deal. I would like to hear from some of the farmers that may be here that have planted glandless. Mr. Rathbone is saying that it is good for him to have lower gossypol content because it contributes to his profits. Is this going on back down to the farmer? We keep talking about premiums.

It is hard for the mill to say "grow glandless and we will give you a premium," if there are not certain limitations. If lower gossypol content seed is grown then somewhere along the line that should be a premium to the farmer. If gossypol content is put on the grade card or otherwise reflected when the farmer sells his seed as is now done between the gin and oil mill it would contribute to a bonus situation that the farmer could easily see and could begin to get the ball rolling. I would like to hear if there are any comments on that end of it.

C. R. RATHBONE To explain my position, I have to run a Cooperative, and all that dollar goes back to them. I was speaking, however, nationally for all of the oil milling business. More and more seed is being purchased on a grade basis. In fact, someone in Lubbock when I was there at one meeting suggested that we ought to have this in our grading formulas and the rules changed perhaps, and he suggested that we were looking at this in the wrong way. Instead of just paying a premium for glandless or a reduction, maybe we should just start charging a discount for the amount of gossypol included in the seed. That is another way to look at it. So I am sure that the development of better quality seed eventually will get back to the farmer.

A. L. VANDERGRIFF I would like to say something in regard to gossypol in relation to how it affects the use of meal in poultry rations. I have seen charts and I am sure all of you have, and George, you are much more familiar with this than I am, I do not know why you did not go on and say it. Maybe I am out of order but the percentage of the ration that can be cottonseed meal is determined entirely by the gossypol level. So, if you lower the gossypol a greater percentage can go in to replace the higher cost soybean meal.

J. M. BROWN It has been mentioned here and I do not think anybody will argue with the fact that from the standpoint of the processor and end use, it is good to get the level of gossypol down. It has also been mentioned here that there is the possibility of some pest problems with glandless. I think H. B. Cooper mentioned this. If gossypol is lowered to 9/10 of one percent, do you notice any difference in susceptibility to pests? How far down could we go without getting into trouble with insects?

H. B. COOPER My answer to your question is that we don't see any insect tolerance difference between Acala SJ-2 at 1.25 as compared to SJ-4 and SJ-5 at .85 to .90%. To answer your questions as to how far we can go, we do not really know, Jim. We have one cotton that has about a .25 gossypol content. We have not had insect problems to really test this cotton. I think Henry Webb has one that has a gossypol content in this range, don't you Henry? The thing that I think we are going to have to do as breeders, Jim, is to develop cottons having an array of gossypol levels, from low to high, if we can. We have started this in our program to see how many points of gossypol levels we can get established and perhaps, we can go into testing to determine whether we see differences where the breaking point in insect tolerance exists. If gossypol truly conditions insect resistance perhaps then we can establish this breaking point.

W. H. WESSLING Dr. Cooper, did you see any differences between those glandless strains you got from New Mexico? They are reporting that they had some differences in resistances to the bollworm.

H. B. COOPER No we did not. We did not have any bollworm nor Lygus, however, and thus, were not really able to make comparisons.

A. CARNRICK It has been stated that many are thinking about having their cottonseed tested for gossypol. I represent an independent laboratory that does a lot of oil mill grading and my question is, if the independent laboratories offer this test, are the mills going to be willing to pay the extra price? Because the test is very tedious and very expensive.

C. R. RATHBONE Well, that's simple. We do our own testing.

W. H. MARTINEZ I think the gentleman was quite right in his description of the procedure. I alluded to that in my remarks earlier. I think this is a real research need. We need better methodology for gossypol, not only more accurate but it should be easy and cheaper. Naturally, if it is rapid and easy it should be lower in cost. I would like to ask Mr. Helm why he ended on the note he did? I believe he was essentially saying he would not recommend that these glandless strains be released. Is this merely a concern that they will not perform?

J. L. HELM No, the concern is that we do not make a change unless you are going to change to something better. Where we do not have a market, and the ginner and the oil miller do not have a special market in the Southeast at the present time, we see no reason to change because the varieties that are equally as good are really not better for that use--for lint production by the farmer.

S. P. SENGUPTA I have a comment. I do not know the exact procedure independent laboratories use to determine gossypol content. Perhaps, it might be feasible to follow a procedure similar to one we have used. We have used chromatography to analyze for amino acids. Gossypol is a chemical compound which may be detected by ultraviolet light. It is only a suggestion, but perhaps it might be possible to cut seeds, stain them with a solvent, and use an ultraviolet lamp to ascertain the gossypol content.

W. H. MARTINEZ Essentially what you are saying Dr. Helm, is that in the Southeast even though you have a problem with oil color and, potentially gossypol is a very real part of that problem, the release of glandless varieties really would not give the farmer any advantage. I think this points out a problem in the whole system, and that is that the real return for the seed is really not identified.

J. L. HELM Very true. You know, if we take a larger look at the problem, for example, that reduction in gossypol would be better for society because of the end use of our products and this sort of thing, we might be willing to admit that the farmer does not have to have any increase in value as long as he does not take a significant risk of having a decrease in productivity. If the farmer only gets the same by growing a glandless variety as he gets from a glanded variety and does not take any additional risk, it really should not make any difference to the farmer. And, if the product that he produces benefits society, then we would all profit. None of us in the seed industry today, with exception of maybe a few people in the High Plains, have been able to convince many farmers that growing glandless cottonseed is not taking an additional risk.

VIEWPOINTS AND DISCUSSION

The Seedsman's Viewpoint

By Delbert C. Hess

I believe, after listening to the speakers that summarized the performance of glandless cotton varieties in the four general cotton growing regions of the U.S., that we have to conclude that the U.S. cotton breeders have done a remarkably good job in taking the glandless characteristic that was described some 19 years ago and developing varieties possessing this characteristic along with the other attributes necessary to make varieties successful. It hasn't been nearly as easy as was first expected, and of course it is still a continuing effort. If the difficulties that were to be encountered in developing glandless varieties had been known at the beginning, some research workers may have channeled their efforts into other projects. However, the general agreement that the use of the glandless characteristic would be very beneficial to the cotton and perhaps food industry has been enough to perpetuate the research projects in this area.

In an effort to supplement the results discussed by the previous speakers, I would like to share some previously summarized data concerning the performance of glandless strains throughout the cotton belt. A little more than a year ago, several of the cotton breeders across the U.S. were asked to furnish data concerning glandless and glanded variety performance in their programs. In the survey each breeder was asked to compare his best glandless strain with that of a widely grown glanded check variety. The results of the survey are shown in the accompanying table. The performance of each breeder's best glandless strain in relation to the glanded checks is shown across the bottom of the table. You will notice that the yields of the glandless strains ranged from 98 to 111 percent of that of the glanded checks. This information was supplied by breeders from across the cotton belt; however, the California data was not included since it has been well established that the performance of the glandless strains in that area is associated with insect (lygus) damage. The California data indicate essentially the same results as the other data in the table, if the tests were grown in lygus-free areas. The data presented today by Dr. Cooper in Table 11 showed that when tested over four locations in 1977, the best glandless strain produced 102 percent as much as the newly released glanded variety SJ-5 and 108 percent of that of the older but widely grown variety, SJ-2.

There is one other point concerning the total breeding effort on glandless cotton varieties that I would like to make. The U.S.

LINT YIELDS OF ADVANCED GLANDLESS STRAINS AND GLANDED CHECKS IN SOME U. S. COTTON BREEDING PROGRAMS. 1975.

	BREEDING PROGRAM						
	1	2	3	4	5	6	7
	POUNDS PER ACRE						
BEST GLANDLESS STRAIN	671	994	842	960	647	804	735
GLANDED CHECK	682	929	828	978	599	723	729
	PERCENTS						
PERCENT OF CHECK	98	107	102	98	108	111	101

GLANDLESS COTTON BREEDING PROGRAMS IN THE U. S. 1976.

cotton breeding programs actively involved with glandless development and/or evaluation are shown in the accompanying figure. Twenty-two such programs are identified on the figure, making the total effort rather substantial. You will notice that three breeding programs are directed toward the development of only glandless varieties. I know of no breeder that has completely given up on glandless although a few have deemphasized it, at least in certain areas.

So if we accept the premise that breeders have in fact developed glandless cotton varieties that perform essentially

equal to the established glanded varieties, why aren't seedsmen selling large volumes of glandless planting seed. On the other hand, we might ask why should the seedsmen, who have been selling glanded cotton planting seed for several years, make a concentrated effort to market seed of glandless varieties. The fact is that seedsmen have not been able to see a way to increase net profits of their business by adding glandless planting seed to their product line. Although producers have, in some instances, been given a small premium for growing glandless varieties, there has not yet been a significant producer demand for glandless cotton planting seed. If and when glandless cottonseed products demand enough premium that the producers will have a real incentive for growing glandless varieties, the seedsmen stand ready to develop, produce and market seed of glandless cotton varieties. Hopefully, other phases of the industry are now ready to help initiate the change to the more desirable glandless types.

DISCUSSION

D. C. HESS While I have the floor, I would like to comment about the possible rodent problem that was referred to earlier today. I think that those of us on the Plains that have seen plots of various sizes all the way from ten foot rows to hundred acre fields feel reasonably sure that the rodents are not a problem on the Plains of Texas. Now what it is in other areas we are not certain and maybe in other countries, in South Africa for instance, there may be some areas where rodents are a real problem. But I know of no area in the U.S. where the rodent problem is really significant when we start growing glandless cotton on large acreages. If someone would like to disagree with that, I welcome their comment but I wanted to make it clear that I did not want everyone to think that the rodent problem was a real significant one, industry-wide.

I have one other comment in defense of cotton breeders. You know we have been working on glandless cotton for some 18 years now. The breeders active in the late 1950's took the material that was described by Scott McMichael and worked for 18 years or so with this glandless characteristic and have apparently made some real progress. I think that attendance and interest today at this meeting certainly substantiates the fact that there has been a lot of progress made. But individuals throughout the cotton industry tend to think that if they have problems, the breeder can solve them all. But, I would remind you that it took 18 years to get here, so if you want to throw us another problem like breeding lower gossypol levels, remember that it is a long process. Also, those of us that maintain both glanded and glandless programs have to handle the programs separately because of isolation problems. Now if we are going to get into another area of breeding partially glanded, we are talking about maintaining a third program. And, of course, in addition to the breeding of the intermediate glandless types, we also, as we realize more and more, need to add some host plant resistance characteristics like nectariless, frego bract, etc. And so in defense of the breeders let me say that breeding is usually not a quick solution

to the problem and that we need to be certain, before asking breeders to solve the problem, that the requested change in varietal characteristics is in fact desirable and usable by the industry.

The Grower's Viewpoint

By D. Pustejovsky

I am glad to be identified as a farmer. I am real thankful for whoever put this program together. With this much brainpower surely we can do something. I certainly concur with Wolf Wessling. I believe he said awhile ago that he believes that we can grow glandless cotton successfully and competitively if we put our minds to it. This is what I assume we are trying to do here today and tomorrow, trying to get our minds together and see why we have not made any more progress in the past and what it is going to take in the future. Several of the comments from Hervey Evans and Jack Francis and others have mentioned incentives and I agree. I might as well tell it just like it is as far as agriculture is concerned. In my operation, the total sales of everything I sell from a piece of ground (and we are talking here of cotton--the lint, the fiber and, if I could, I would sell the stalk and the leaves). The total sales, less the total cost of getting it there, whatever is left, that is my profit. I have got to have a profit to survive. Right now we are surviving on capital. A lot of agriculture today is just surviving on capital with inflated land value. In many cases, the well has gone dry, particularly with the young or those who have overexpanded.

I was interested in the comments that the industry people made about profits and economics. They, too, must have a profit. I do not think that American consumers fully realize these facts, and I do not really see why they should be expected to know. They have been spoiled over a number of years with cheap food through surpluses and different gimmicks. The efficiences of our research programs and our land-grant system have continually produced these benefits. So, I think that our people have become spoiled.

I think we are now seeing the beginning of the process of the dismantling part of our agricultural operation as far as the actual farm operation is concerned. I know that through government edict and through some of the OSHA and EPA regulations we have had some cotton oil mills shut down. Economics has closed some cotton gins and merely the threat of some of these things are shutting down other operations. I know that the availability of credit is being restricted somewhat in our area this year.

I observed with interest awhile ago what is happening in the dairy industry. There are now about half as many people in the dairy business as there were. Yet, with double production, we still have milk. I do not know how much longer this can continue, nor how much more of the squeeze play can take place, but I still say that profits are necessary and they are going to have to come sooner or later. They may come through shortages and

that may be what it will take. I know that the mills--the people that produce materials from our raw products and put them into the finished goods--have to make a profit. So, I say that something is going to have to turn around for the profits are going to have to filter down eventually to the farmer.

I will give you an example. I have been farming 32 years. I do not remember the year, but about 1947, the cottonseed brought an extra good price. I was just a young farmer starting then with very little equity. My Dad rented me one of the farms he owned and loaned me a little money to get started. At that time, in the Blacklands, if we could farm cheap enough and if we could make a third of a bale to the acre, we could stay in business. This was when we were still handpicking the cotton. Now, during those years--I remember one year in particular--the cottonseed paid all the ginning and handpicking costs. So, I produced a third of a bale of cotton per acre at a profit. We did not use very much insecticides then. After Mr. Charlie Parencia developed the early season spray program, we moved from a third of a bale to the acre pretty rapidly up to a bale per acre production. I also remember one more year that I got my ginning paid and I averaged $5.00 a bale above my picking costs with the gin rebate. We did not have cottonseed prices like that again until about 1976 when the rebate on cottonseed averaged about $10 or $15 a bale. However, this time we had our harvest costs to pay. With the cotton-stripper and other efficiencies we were able to make, this rebate almost paid our harvest costs. Cottonseed in 1976 was $105 to $110 a ton.

This year is another story. A lot of the state of Texas may have produced a real good crop this year. We did not do quite that well in the Blacklands and we did not break even on a lot of our cotton. But this year we had all our stripper costs and extra defoliation. On top of that, our ginning costs ran from $18 to $32 per bale above the return on the seed. This was with a lot of half a bale per acre production. With the price of seed down to $50/60/ton, you can see we are in a real tight squeeze.

As I said before, I agree with Dr. Wessling. I believe that after we have put our minds to it, we can certainly solve the problems. I would very much like to see a full-scale test from production through ginning, seed storage, manufacturing, and utilization on a scale large enough to see how to work out the problems in the system. I think we can do it. I have seen many experimental glandless cotton plantings by Drs. Ray and Bird and have seen some of the new lines other cottonseed companies have in some of their plots. I am convinced that here in Texas we can grow glandless cottonseed. I think we will move and we can adapt very rapidly. I think our response and the ability of the American farmer to respond has been proven. All that is needed is to show them a little incentive. We see what the incentive in price did to grain. We can go from almost empty bins to surpluses in a short period of time given a little assistance by the weather.

I certainly appreciate being here. I have followed the work of the seed companies and research people over a number of years, and it makes you really appreciate them when you go other places

in other countries and see what is happening there. I think all of us underestimate or do not fully appreciate what we have in this country today. I think we can solve our problems. Some of them are political. Some of them are just the fact that we have become complacent, but I think we can do a lot of things we have not even dreamed of yet.

ASSESSMENT OF PEST MANAGEMENT FOR GLANDLESS COTTON: AGRONOMIC VIEWPOINT

By Johnie N. Jenkins

The successful production of a crop of cotton, Gossypium hirsutum L., depends upon a number of things, including the interaction of the cultivar with the environment in which it is grown. The term pest management usually refers to the management of all living things which may become pests upon the variety. Diseases, nematodes, and insects are the main organisms of concern.

In pest management we must consider the complete interaction of the cultivar with all elements of the environment in which the crop is grown. This interaction includes cultural practices such as tillage, planting date, spacing, and such other factors as herbicides, moisture stress, fertilizers, insecticides, defoliants, insects, diseases, and nematodes. Thus the subject of successful growth of a cultivar is a complex one. The cotton breeder must develop a cultivar that successfully produces a profitable yield under the conditions in which it is grown.

As a hypothetical situation, would we recommend cotton to growers as a new or alternative crop today? Would we recommend that growers begin to produce a crop that requires the inputs and careful management that cotton does? What would we tell growers about the many insects and diseases that successfully attack cotton?

As we look at a new cultivar or strain of cotton, do we consider it in the same way we now consider our presently grown cultivars: do we ask that a new type (for example, glandless) compete with presently grown cultivars under identical growing practices or do we ask that the new cultivar compete without the help (such as insecticides) that presently grown cultivars require? We sometimes make unfair comparisons and stress the proposed new strain in situations under which even the presently grown cultivars cannot produce a profit. Then when the new strain cannot compete under this 'stacked deck' situation, we decide that it has problems that must be solved before it can be recommended.

These questions indicate that the way we compare two cultivars can affect the conclusions that we draw. No one production system or pest management practice works all the time everywhere. We just do not have that kind of broad control over the environment.

For example, cultivars A and B may be compared for the rate of development of a particular insect. Cultivar A may produce insects significantly larger than cultivar B. However, if both or either are to be grown under conditions that normally require insecticides to produce a profitable crop, we can logically ask the question, "How do we relate the larger insects produced on cultivar A to profitable production of cultivar A?" It may not make any difference which cultivar is selected if insecticides effectively kill insects on both cultivars and are normally required on both. Thus, the production

system one uses can have a direct bearing on the significance of the growth rate of the insect on cultivars A and B. Production cost and yields for different cultivars might be equal under some systems and sharply different under others.

For a new or proposed cultivar such as glandless to be successful, it must equal or surpass presently grown cultivars in profit or it must not reduce total profits to the farm enterprise. With cotton, this generally means equality of the following characteristics under the best available production strategy: lint yield, lint length, lint strength, lint micronaire, earliness, and sensitivity to insecticides, herbicides, and traditional environmental stresses. The new cultivar must compete favorably in the state yield trials before very much seed is sold. It may compete favorably in a region, one state, or only part of a state, and thus it may become an important cultivar in that area. If the area is large enough, it creates a profitable demand for seed and the cultivar is thus established. A balance between economy and risk determines the success or failure of a proposed cultivar.

As we try to apply some of this broad-range thinking to glandless cotton, we can divide the subject into several areas. All of the following areas must be considered. In this manner we can best determine how to move a new cultivar or type such as glandless into profitable production.

AGRONOMIC PROPERTIES OF GLANDLESS COTTONS

Hess (1977) reviewed information on the glandless cultivars from several standpoints (Table 1). He compared data on glanded and glandless cottons from seven breeding programs. In two of the programs glandless strains yielded 2% less than glanded. In five programs the strains were from 1% to 8% higher in yield than their glanded check cultivar. A survey of the agronomic data from Texas, Louisiana, and California (Anon. 1976, Ray and Supak 1977) showed that under conditions of proper insect control yield, lint quality factors, and earliness of glandless strains were equivalent to the best commercial glanded varieties in those areas. Thus, we can say from an agronomic standpoint that we have quality glandless strains. Agronomically, glandless and glanded strains are equal.

Quisenberry et al. (1975) grew a composite cross with glandless parentage for 10 generations at Lubbock, TX. The glandless gene was not at a competitive disadvantage in their work; it persisted in the composite cross at the expected frequency for 10 generations. This indicates the environment (disease, insects, nematodes, etc.) of the Texas High Plains did not selectively decrease the yield of glandless plants. They stated that these results were encouraging and suggested that large acreages should be tried.

DISEASE RESISTANCE STUDIES

Not many data are available comparing disease reactions of glanded and glandless cottons. Cauquil (1973) presented data on boll rots by three fungi (*Aspergilla niger*, *Botryodiplodia theobromae* Pat. and *Cercospora gossypii*) that showed that glandless strains were more resistant to boll rots than glanded strains. I have also heard two breeders in the Southeast say their glandless strains had less boll rot than their glanded strains.

TABLE 1.--Comparisons of lint yields of glandless and glanded cotton strains in seven breeding programs in the United States in 1975

	Breeding Program Lint Yields (lbs/acre) in 1975						
	1	2	3	4	5	6	7
Best glandless	671	994	842	960	647	804	735
Glanded check	682	929	828	978	599	723	729
Percent of check	98	107	102	98	108	111	101

From Hess, 1977

TABLE 2.--Bollworm damage in nectariless cottons

No. Bollworm Damaged Squares in Nectariless Cottons		
Year	Reference	% of Normal
1971	Laster & Meredith	84.3
1972	Laster & Meredith	77.5*
1973	Schuster & Maxwell	42.3*
1974	Schuster	123.6

* Indicates significance at 0.10% level

From Meredith, 1977

TABLE 3.--Effects of Various Cotton Strains on Heliothis Population and Yield

Strain	Characteristics	Larvae Per Hectare	Seed Cotton Kg/ha
La 17801	Smooth nectariless	137,106	1,775
Mo 35601	Pubscent high gossypol	141,494	1,685
HG 6915	Smooth high gossypol	202,913	1,412
HGA-4	Nectariless medium gossypol	194,142	933
ST 7A		253,371	348

From Camplis et al., 1976

HERBICIDE RESISTANCE STUDIES WITH GLANDLESS COTTONS

Not much work has been done on herbicide resistance in glandless cotton. However, differences between glanded and glandless strains in their tolerance to commonly used herbicides would have been indicated in state variety trials and nurseries. McCall (1976) compared 70 cotton strains for tolerance to 5 herbicides in Oklahoma. One of the 70 strains was glandless and was less tolerant than glanded strains to Floumeturon and Prometryn. However, two glanded lines were also less tolerant than other glanded lines to these two herbicides, and one cultivar more tolerant than the average. Thus, McCall (1976) could not be sure if the background or the glandless condition was responsible for the increase in sensitivity. He did show that the glandless strain absorbed Floumeturon at a faster rate than did glanded strains and that the C^{14} labeled Floumeturon was concentrated in the glands in glanded cotton and was generally dispersed throughout the leaves in glandless. For 1978 CIBA-GEIGY who manufactures Prometryn under the trade name Caparol 80W has included the following caution on their label: "Do not use on glandless cotton as crop injury will occur" (1978). Because we know that soybean cultivars differ in sensitivity to herbicides it behooves us to examine it in cotton strains.

INSECT RESISTANCE STUDIES WITH GLANDLESS COTTONS

There is much literature on laboratory tests and field observations of serious and occasional pests but not much on pest management with glandless cottons. The following serious cotton insects have shown a preference for glandless cotton when given a choice: Cotton bollworm, *Heliothis zea* (Boddie); Tobacco budworm, *H. virescens* (Fab.); Pink bollworm, *Pectinophora gossypiella* (Saunders); Lygus, *Lygus hesperus*; and probably L. *lineolaris* (Beau.). There are also a number of insects that do not normally attack cotton but that do damage glandless cotton. Boll weevils, *Anthonomus grandis* Boh.; spider mites, *Tetranychus urticae* Coch.; and fleahoppers, *Pseudatomoselis seriatus* (Reuter), damage glanded and glandless cottons equally (Jenkins et al. 1967, Lukefahr et al. 1968, Schuster et al. 1972, and Rummel 1975). As would be expected, there is considerable evidence that indicates all glandless strains are not equally susceptible to insects. However, the glandless trait usually increases the susceptibility of the cultivar to several important insects that are cotton pest.

Two additional cotton characters can be bred into glandless cotton and should greatly decrease the insect damage. These are smoothleaf and nectariless. Available data show that a glandless-smooth cotton strain received fewer bollworm eggs and less larval damage than a glanded normal-pubescence strain (Oliver et al., 1970).

Calderon (1977) showed that egg laying by *Lygus lineolaris* females was reduced 75% on nectariless strains when compared to cotton with nectaries. Wilson and Wilson (1977) showed that pink bollworm damaged about 50% fewer seed on nectariless cotton strains and that the nectariless strain out-yielded nectaried strains in field tests.

In 3 of 4 years researchers reported that bollworm damaged squares in nectariless plots were reduced 16 to 58% (Table 2). One year they reported a 24% increase (Meredith 1977, quoting Laster and Meredith, Schuster and Maxwell and Schuster).

Camplis et al. (1976) presented results from four experimental cottons and 'Stoneville 7A' grown without insecticides at Tampico, Mexico (Table 3). The smooth and nectariless La 17801, the highest-yielding strain in the test, yielded five times more seed cotton than did Stoneville 7A. Larvae per acre on this smooth-nectariless strain were slightly lower than that on a normal-pubescence-high gossypol strain and far lower than that on another high gossypol strain with smooth leaves and nectaries.

Culp et al. (1977) showed that their strains had an unidentified source of resistance to *Heliothis* spp. that was equivalent to the resistance in the high gossypol-nectariless strains. This source was in several Pee Dee frego lines.

Several researchers, including myself, have shown that nectariless, smoothleaf and the Pee Dee frego lines and combinations of them vary in degree and significance of resistance to *Heliothis* spp. complex, pink bollworm, and Lygus. Thus, a breeding strategy is emerging in which these traits are combined with glandless and the resistance of the resulting cotton strains is determined.

In 1975, Rummel (1975) surveyed the insects in glanded and glandless cotton fields on the High Plains of Texas. His data indicated that: 1) glandless cultivars in general suffered less damage from thrips (*Frankliniella* spp.) than did glanded ones, 2) aphid populations in glandless cultivars were smaller than those on adjacent glanded strains, 3) little difference in flea-hopper damage was noted in the glanded and glandless strains, and 4) the glandless cottons were more susceptible to bollworm (*H. zea*) damage. Rummel concluded that, on the basis of the one-year study, glandless cotton probably must be produced with close surveillance and good management to prevent economic damage from bollworm. Preliminary results of a similar experiment in 1976 indicated that the conclusions were essentially the same as those reached the previous year.

BREEDING STRATEGY FOR COUNTERACTING THE INSECT SUSCEPTIBILITY OF GLANDLESS COTTONS

Although we have developed agronomically superior glandless cottons, their seemingly increased susceptibility to *Heliothis* spp., pink bollworm and Lygus may present problems in growing them. The proper pest management trials should be conducted.

Several of the following genotypes should be developed in each of the glandless cotton strains: Glandless-nectariless, glandless-smooth, glandless-smooth-nectariless, glandless-Pee Dee factor, glandless-nectariless-Pee Dee factor, and glandless-nectariless-smooth-Pee Dee factor. We should then evaluate these types in pest management programs. Glandless cottons may thus develop some normal reaction to the major three insects when these resistance factors are bred into them. However, we cannot know this until it is done.

NEED FOR PEST MANAGEMENT TRIALS WITH PRESENT GLANDLESS COTTON STRAINS

Most of the available data on insect damage to glandless cottons is taken from feeding trials, caged plants, or very small plots not sprayed with insecticide. Apparently data from glandless cottons treated with insecticides and other pest management techniques are not available. I propose that limited trials should be conducted in the areas where *Heliothis* spp. are a

problem especially in the Mid-South and Southeast. They may also be important in California and on the High Plains of Texas, where larger acreages have already been grown. These trials would compare glanded and glandless strains under the best programs we can manage. The best programs would use all pest management components (insecticides, natural enemies, and biological control agents, such as viral or bacterial preparations) as they are needed. We do not have data to determine if we can produce glandless cottons under our best management systems. We are now applying large amounts of insecticide to our glanded cottons. We should know how glandless cottons would perform under the same conditions. At the same time these data are being obtained, breeders should develop the glandless strains with nectariless, Pee Dee factor, and smooth in various combinations.

PEST MANAGEMENT TRIALS WITH GLANDLESS COTTONS WHICH HAVE ADDITIONAL SOURCES OF RESISTANCE SUCH AS NECTARILESS OR SMOOTH

After breeders have developed good glandless strains that also contain the nectariless, smooth, and Pee Dee factors in various combinations, the lines should be placed in pest management trials to determine their potential. It should only take breeders 3-5 years to develop these strains, because they already have agronomically adapted glandless strains, nectariless strains, smooth strains, and Pee Dee strains. Thus, combining them with glandless should not be an insurmountable task. However, I do not wish to imply that it will not take time, money, and a lot of work. These efforts should be undertaken if we can determine the potential for glandless with some of the insect problems solved. Much of the data suggests that breeders can successfully return glandless cottons to the level of resistance (or susceptibility) of present glanded cottons.

GLANDLESS STRAINS IN STATE CULTIVAR OR NEW STRAINS TESTS

Little effort would be required to enter the best available glandless cultivars or strains in state yield trials or new strains tests. They would receive the same production and management practices that the glanded varieties now receive. The glandless strains would grow on the farms of leading growers, because the tests are usually conducted on them. I believe much information could be gained from a few years of this testing in the Mid-South and Southeast. We should consider planting the glandless strains in a separate test at each location. Texas already tests glandless strains on the High Plains. California enters glandless strains in their variety trials. In California they have not yet tried pest management that uses judicious applications of insecticide for lygus, because they are striving for a pest management system that does not involve insecticides. The pink bollworm may change this approach to a marked extent. If so, glandless or glandless-nectariless strains plus insecticides should perhaps be tried as a production system. A few years ago, Arizona growers were saying that they would not or could not afford to use insecticides for pink bollworm control. They are now using insecticides as a part of their management system. We usually practice the 'art of the possible' in cotton production.

SUMMARY

The original agronomic data on glandless lines of cotton were not encouraging. Since that time, conventional breeding programs have produced glandless strains with a wide range of agronomic and fiber properties. Some of these strains are equal or superior to glanded lines in yield, agronomic performance, and disease resistance when grown in variety trials in the absence of insects. Very little data are available from the Southeast, where insects are a major problem.

The data show that four important insect pests, two *Heliothis* spp., lygus and pink bollworm, grow better on glandless cottons than on glanded. *Heliothis* spp. appear to be a severe threat. At this time we do not know the effects of growing large acreages of glandless cottons, even in areas relatively insect pest free. Relatively large acreages have been successfully grown on the High Plains of Texas. Several characters are known to give cotton strains greater resistance to lygus, *Heliothis* spp., and pink bollworm. Some of these traits, nectariless, smooth, frego bract and the Pee Dee factors, may be successfully bred into glandless strains to help offset their susceptibility to these pests. The general economic outlook and final markets for glandless cotton may well determine whether this breeding effort is continued. The results of this conference could affect: 1) what breeders do with glandless strains, 2) whether resistance factors are bred into glandless strains, and 3) what type of pest management trials, if any, are researched in the near future.

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ASSESSMENT OF PEST MANAGEMENT FOR GLANDLESS COTTON: ENTOMOLOGICAL VIEWPOINT

By R. L. Ridgway and J. C. Bailey

As most of us know glandless cottons are usually considered more susceptible to insects than glanded cottons, a generality that could, and somehow does, produce negative reactions to glandless cottons. Nevertheless, we should not hastily conclude that growing glandless cottons is impractical for this reason. The principal consideration of the grower is whether there is adequate economic incentive for him to produce glandless cottonseed. Even if the cost of insect control, or the increased risk of insect damage, with glandless cottons is greater than with glanded cottons, production of glandless cottons should not be discouraged if it will increase net economic returns. Also, we should recognize that the development of glandless varieties that will produce acceptable yields of high quality cotton without increased costs due to insect control is a realistic goal.

Decisions affecting the future of glandless cottons should be based on a thorough understanding of the factors involved. Therefore, we will review some of the available information concerning the effect of gossypol and other terpenoids on insects and discuss some means of alleviating the insect losses that may be associated with production of glandless cottons.

EFFECT OF TERPENOIDS ON INSECTS

The chemical composition and biological activity of pigment glands in cotton was reviewed recently by Bell and Stipanovic (1977). These authors compiled many of the references to insects and other herbivores feeding on glandless cottons. Perhaps it would be helpful to review some specific examples.

Cook (1906) was apparently first to recognize the importance of pigment glands to host plant resistance to insects; however, his comments did not receive much attention until after the discovery of cottons without pigment glands in 1959. Perhaps the first controlled tests of the effect of gossypol on insects were those conducted by Bottger et al. (1964). They found that application of foliar sprays made up of plant extracts containing gossypol produced high rates of mortality of cotton aphids (100%) and lygus bugs (90%) and significant mortality of boll weevils (40%). Later, in studies with gossypol in insects diets and with glandless plants, researchers found that the development of some species of insects was partially related to the absence or reduction of gossypol and/or pigment glands. Included were such insects as the bollworm, tobacco budworm, and pink bollworm (Lukefahr et al., 1966; Shaver and Lukefahr, 1969). In addition, on the basis of data for percent egg punctures and oviposition ratio, the boll weevil preferred feeding and egg laying on normal-glanded or glandless cottons rather than on high gossypol strains (Sing and Weaver, 1972). Lygus bug nymphs on glandless

cotton had growth rates and survival nearly double those on isogenic glanded lines (Tingey et al., 1975; Benedict et al., 1977). Also, Meisner et al. (1977) found consistently negative correlation with larvae of Spodoptera littoralis between feeding rate and the concentration of gossypol applied to styropor lamellae: at 1.0 and 0.5%, feeding was strongly inhibited; at 0.25%, larvae fed about half as much as in the control; and at 0.1%, there was practically no deterrency.

In addition, a relatively large number of additional insects and other animals have been reported to feed extensively on foliage or seeds of glandless but not glanded cottons. These include the spotted and western spotted cucumber beetles, flea beetles, the grape colaspis beetle, the dock beetle, striped and ash-gray blister beetles, and the Japanese beetle; non-insect pests include pill bugs, rodents, rabbits, and pheasants (Bell and Stipanovic, 1977). In Nigeria, flea beetles fed on the leaves and bracts of Empire glandless cotton so severely that growth was inhibited through loss of photosynthetic tissue (Lyon, 1970). Also, the striped blister beetle has been known to strip the lower leaves from both Acala 4-42-77 glandless and Rex smooth leaf glandless lines but did not feed on glanded Deltapine smooth leaf, Rex smooth leaf, and Acala 4-42-77 (Maxwell et al., 1965).

Although there are many reports of susceptibility of glandless cotton to pests within the United States, the insects of most concern apparently are the bollworm, tobacco budworm, and lygus bugs.

APPROACHES TO DEALING WITH SUSCEPTIBILITY OF GLANDLESS COTTONS TO INSECTS

Although susceptibility of most glandless cottons to insect pests is a basis for considerable concern, there are at least 4 possible approaches to dealing with the problem: (1) grow glandless cottons in areas where there is the least risk of insect losses, (2) develop economical and acceptable methods of controlling the additional insects on glandless cotton, (3) develop host-plant resistance characters to neutralize susceptibility associated with glandless cotton, and (4) develop lines that have glands in leaves and flower buds but not in seed. Perhaps a brief discussion of these approaches will give us some insight into their potential.

Grow in least risk areas. The High Plains of Texas and possibly the San Joaquin Valley of California are considered the lowest insect risk areas in the United States. Therefore these areas, and particularly the High Plains of Texas, should provide the greatest opportunity for production of glandless cottons with the least risk of insect losses. Experience has confirmed this to be the case since some 20,000 to 50,000 acres of glandless cottons are produced in the High Plains of Texas. Also, what may well be the only definitive studies of insect populations on sizeable plantings of glandless cotton have been conducted in that area by Dr. D. R. Rummel of the Texas Agricultural Experiment Station. Dr. Rummel has completed a 3-year study in that area and has not reported any major insect problem on the commercial plantings of glandless cottons. However, there were significantly larger population increases in bollworms on glandless plantings at one location than on commercial glanded cottons.

Use of additional insect control measures. Theoretically, if the value of glandless cottonseed was great enough, farmers could afford to apply additional insect control measures and still increase their net income. However,

in view of the current difficulties and rising costs associated with insect control on cotton, practices that will significantly increase needs for insect control are questionable.

Insect-resistant glandless cottons. There is substantial evidence that differences in insect susceptibility are substantial among different sources of glandless cottons. Thus, the development of insect-resistant glandless cottons has some real possibilities. This point can be illustrated by data from a study by Oliver et al. (1970) in which a number of isogenic glandless and glanded lines were compared in relation to the bollworm. The research showed striking differences among lines. In fact, some glandless lines appeared to be less susceptible to bollworms than their glanded counterpart.

Because of the potential of developing insect resistant glandless lines and because of the value of using glandless backgrounds in searching for host plant resistance that may be used in glanded lines, the Agricultural Research Service recently expanded its efforts at Stoneville, Mississippi, to undertake such a search. Over 100 genotypes of glandless cottons are currently being evaluated. In the initial evaluation during which newly hatched tobacco budworm larvae are bioassayed on plants in the 2- to 4-leaf stage, substantial differences have been found. Some of the most tolerant genotypes will now be field evaluated, and, if they continue to show promise, they will be combined with other genotypes that have characters known to provide insect resistance.

A similar evaluation program is underway at Shafter, California, by Dr. T. F. Leigh and his colleagues. There, though the advanced Acala glandless lines are known to be more susceptible to lygus bugs, some of the 70 lines evaluated in whole plant cages in the greenhouse have been shown to be no more susceptible to lygus than current commercial Acala varieties.

Glandless seed and glanded leaves and flower buds. Perhaps the ideal situation would be varieties of cotton with pigment glands present in leaves and flower buds but not in seeds and a genetic character sometimes referred to as "delayed gland morphogensis" provides this potential. This character occurs in both *Cienfuegosia* sp. and in the Australian wild cottons (Bell and Stipanovic, 1977). The initial cells for gland formation occur in the embryos of these species, but there is no deposition of terpenoids until after germination begins. Once seedlings emerge, glands are fully developed and contain terpenoids. Although incorporation of this character into acceptable varieties would require a long-range effort, it would seem to be the ideal approach to dealing with the insect problems that may be associated with glandless cottons.

CONCLUSION

Many studies indicate that terpenoid pigments associated with glanded cottons are toxic to insects. Therefore, glandless cottons may be associated with an increased risk of insect losses. However, insect susceptibility among glandless cottons varies greatly, and there is some evidence that some glandless varieties may not be any more susceptible to insects than some glanded varieties. Several approaches can be taken to reduce, if not eliminate, the additional risks associated with insect damage on glandless cottons. The emphasis placed on one or more of these approaches will be directly related to the amount of economic incentive associated with growing glandless cottons.

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DISCUSSION OF PEST-MANAGEMENT PAPERS

J. R. SMITH Are rabbits, rats, mice, and other animals considered to be a problem of consequence to glandless cotton?

R. L. RIDGWAY There are a lot of isolated reports about rodents feeding on glandless cotton; you go through all the literature; it seems to be a unique situation. My general impression is that rodents will not be a major problem. One of the questions I specifically asked Don Rummel was whether or not unusual pests showed up anywhere in his tests on the High Plains. He said "no." So, I do not think we should be overly concerned. I think it is just something we should watch. Also, I do not think you can judge the problem in small plots. Personally, I am not nearly as concerned about rodents as I am about the bollworm-budworm complex and lygus bugs.

A. L. VANDERGRIFF There seems to have been some questions in people's minds yesterday from questions that were asked about whether or not we are really ready to go to the farmer and say, you should grow glandless, it is economically feasible to grow. In trying to put that in its proper perspective and trying to find an answer, it seems that Dr. Jenkins was pretty optimistic that maybe for the South and Southeast, the insect problem might not be so serious. We might be ready to say, "yes," we can grow it. In Dr. Ridgway's remarks, he leaves one option open I believe at the present time where he feels that we might be able to move, and that would be in the areas where insects would not be such a problem, such as the plains of Texas. Now, the other options left would require considerable or at least some further work in the way of insect testing and pest management programs. Is this a fair appraisal of where we stand, as far as insect management is concerned, Dr. Jenkins? Dr. Ridgway, would you just give us a brief summary of where you think we really stand? Or can we go away from here and say to the farmer, we are ready to do this?

J. N. JENKINS I think it would be misinterpreting what I said, if you concluded that we are ready to grow glandless cotton in the Southeast. What I wished to imply was that we do not have any actual trials in the Southeast to determine how glandless cotton would perform under insecticide-controlled conditions. I think if we intend to consider growing the glandless cotton in the Southeast, it is time to start looking at some of it and some trials, but not in farmer production.

R. L. RIDGWAY Maybe I should say a few words about why we have to be rather cautious in some of these areas. Since some of you are not familiar with the pest situation, I will briefly review it. The Cotton Incorporated Board of Directors in their September meeting passed a special resolution in which they expressed extreme concern about both our inability to control the "worm" complex on cotton and the extremely high cost. The fourth regional meeting will be held tomorrow here in Dallas where we will hear producers and other interested parties review the situation. There are a number of areas in this country where producers

spend a great deal more on insecticides than they can afford. We are hearing growers report expenditures as high as $130 to $140 an acre; most growers absolutely cannot pay these costs and continue to grow cotton. So, growers in those areas where insect control costs are escalating, are already beyond what they can afford to spend and stay in business--I have to be cautious about saying we are ready to grow glandless cotton in those areas. At the same time, however, I agree with Dr. Jenkins that there are many areas where we have not seen glandless cotton grown under field-size conditions so that we could determine whether or not there would be an increased pest problem. Certainly, the only way you can really determine if glandless cottons will aggravate the pest problem is to look at glandless under realistic conditions. The fact that our seed firms tell us they have materials that are ready, but do not want to release them in these areas, is also basis for caution. We have been passing the buck for the last couple of days by saying if the mills or the food industry would provide adequate incentive we would grow glandless cottons. As an entomologist, I do not want to pass the buck, but there just has not been the interest in the higher insect pest risk areas to justify large-scale testing. Perhaps out of this two-day session, we will see interest developed to the point that we should take that step.

R. J. MIRAVALLE How many years of management trials do you think would be necessary - in any one region of the cotton belt - before we would be able to determine the question of proper management for glandless cotton?

R. L. RIDGWAY It depends on how big a risk you wish to take. Researchers are always conservative and every year is different.

R. J. MIRAVALLE I am only asking for your opinion.

R. L. RIDGWAY I look at three years minimum for obtaining an understanding of a situation as it relates to insect populations. I think my plant breeding friends usually say it takes more than three years to find out how a particular variety will perform.

BREEDING GLANDLESS COTTONS FOR DISEASE AND INSECT RESISTANCE

By L. S. Bird, J. H. Benedict, F. M. Bourland, L. Reyes, D. L. Bush and R. G. Percy

Developing cottons having disease and insect resistance has been a serious challenge for many scientists working with cotton. Meeting the challenge in glandless cottons will give double dividends for a crop that provides fiber and food with no limitations on use. Current trends concerning energy, the use of pesticides, pollution standards and world food protein needs inject a sense of urgency for researching glandlessness in cotton. Disease and insect resistant glandless cottons will permit more economical production of the basic raw materials cellulose, food protein, oil and roughage in management systems which are efficient in using energy and natural resources.

Hindsight must be used in planning for the future. Considerable information is available for genetic improvement for disease resistance and the pool of knowledge for insect resistance is accumulating daily. The good and bad experiences from many years of disease resistance research can be used to make improvement for insect resistance more effective.

We will give an analysis of the past and present as a basis for emphasizing a plan for developing disease and insect resistant glandless cottons.

DEFINITIONS

A strong argument for the importance of genetic background will be made and for this reason a definition is needed. For our purposes, a genetic background is determined by the composition of minor and modifier genes. With some exceptions, all varieties of *Gossypium hirsutum* L. have a similar composition of major genes. However, cotton varieties can be grouped on the basis of having distinct combinations of minor-modifier genes. These minor-modifier genes condition the basic differences between groups such as the Cokers, Stonevilles, Deltapines, Lankarts, Paymasters and Acalas.

Resistance will be defined as the response of a plant to agents of adversity in which symptom level and damage are less than those expressed by a known susceptible type. It is important to recognize that several levels of resistance may be progressively attained during the course of researching host response to an adversity. We describe the initial departure from full susceptibility as partial resistance, the next as resistance and the third as high resistance. Generally, it is easy to distinguish high resistance and resistance to an adversity, but it takes special efforts to recognize partial resistance. When researching for resistance to an adversity for which none is known, the partial level is usually the first to become available. High resistance developed from different partial sources is usually more effective and reliable for controlling an adversity. Several sources of partial resistance may be used to gain gene recombinations giving resistance. Different sources of resistance may then be

used to achieve high resistance. Historically, such progressive improvement has been the rule especially when dealing with root diseases.

It should be understood that while cultivars with partial resistance and resistance are superior to susceptible ones, they can still be damaged by high populations of causal agents. Practices which prevent increases in populations of disease organisms and insects usually give an effect which is additive with resistance. Thus, the use of cultivars with partial resistance and resistance in conjunction with management practices aimed at reducing losses can often provide adequate control of adversities.

GENETIC BACKGROUND

A minor-modifier gene background which is receptive and allows a favorable expression of resistance genes is the key to successful genetic improvement for disease and insect resistance (Bird, 1973). Otherwise, a long frustrating task may be experienced in achieving any degree of success. The senior author was not successful in developing Empire, Deltapine, Stoneville, Coker and Acala types with high resistance to bacterial blight. The objective was changed to developing disease resistant cottons with no variety type in mind. This led to development of a receptive background in which high resistance then immunity to bacterial blight was obtained. This is a simple example but it illustrates the concept that must prevail for the successful development of disease and insect resistant glandless cottons. The challenge of multi-adversity resistance is much greater than the development of bacterial blight resistance because the background must be receptive to genes conditioning resistances to all major and minor diseases and insects.

Effective use of the okra leaf, frego bract, glabrousness and nectariless characters must be made. Many programs have had difficulty in using one or more of the morphological traits which suggests a background effect. In our own program the effectiveness of morphological characters in controlling insects has varied with different genetic backgrounds. Therefore, it seems clear that efforts must include development of backgrounds in which the expressions of resistance and morphological traits are favorable.

Many current variety backgrounds, whether glanded or glandless, are poor receptors of genes for resistance and morphological characters. As far as the senior author can discern, every U.S. program will have to be concerned with development of backgrounds if they are to be competitive in improvement for disease and insect resistance.

EXAMPLES OF DIFFERENTIATING BACKGROUNDS

Procedures for identifying or differentiating among backgrounds with respect to reception for favorable expression of genes for disease and insect resistance have not been established. Under the concept of minor-modifier gene effects and with imagination of what is needed we must proceed to develop favorable backgrounds. These in turn may be used in investigations designed to establish procedures for differentiating among favorable and unfavorable backgrounds with respect to the desired expression of resistances and morphological traits. Nurseries at as many locations as possible increase chances of having plantings where adversities occur. Sites known for root diseases should be chosen while choice of sites for above ground diseases and insects may be based on liklihood of occurrence. Every adversity occurring (planned,

TABLE 1. Average performances over 11 locations of glandless (gl_1 gene), necatariless, okra leaf, frego bract, smooth or hairy and red plant color strains of two backgrounds

Cultivar	Average performance rating[a] Mature crop	Total for season
GNORS-Red-1-76[b]	2.4	2.5
GNORH-Red-1-76[b]	2.8	2.9
GNORH-Red-2U-76[c]	4.5	3.5

[a]A rating system in which one represents good, 2 above average, 3 average, 4 below average and 5 poor. Average ratings made after the crop was mature and the total which averages 2 to 4 ratings made periodically during the season are given.

[b]Strains of the MAR background.

[c]Strain of an undesignated background having resistance to Southwestern cotton rust.

TABLE 2. Average of 4 performance ratings for 3 cultivars made periodically during the season in the Brazos Valley nursery where insecticides were not applied

Cultivar	Average performance rating[a]
ORSBO-5-76	2.5
Stoneville 731N	4.8
GNORH-Red-U (77 Prog)	5.0

[a]See footnote a, TABLE 1.

unplanned, major or minor) should be used as a basis for eliminating backgrounds which perform below average.

Priority should be given to locations over replications when seed supply is limited. A system of performance ratings facilitate getting comparative data for many strains at several locations. The use of 10 to 14 locations in our program increases the probability of evaluation in the presence of many different adversities each year. Yield data from a location where an adversity is severe may be extremely valuable.

Average performance ratings for 11 locations were clear in showing that the strain GNORH-Red-2U-76 was a poor background and should be eliminated (Table 1). Because of confidence in the rating system GNORH-Red-1-76 was eliminated because its average ratings were 0.4 higher than those for GNORS-Red-1-76. Performance of the glandless (gl_1 gene), nectariless, okra leaf, frego bract and red plant color strains also serve to illustrate the influence of background on effectiveness of morphological characters. The morphological traits in the GNORH-Red-2U-76 background, which is different from the other strains, were ineffective in reducing insect damage.

Performance ratings obtained at only one location may serve to differentiate background especially when differences are striking (Table 2). Performances of Stoneville 731N (nectariless and hairy) and GNORH-Red-U (Gl_1 glandless, nectariless, okra leaf, frego bract, hairy and red plant color) were poor in the presence of plant bug and *Heliothis* damage. ORSBO-5-76 (okra leaf, frego bract, and glabrous) gave an above average performance. This example also serves to illustrate the effect of backgrounds on effectiveness of morphological traits in reducing insect damage. The GNORH-Red-U progeny is of the same background as the GNORH-Red-2U-76 strain (Table 1).

Yield data for cultivars obtained where severe adversities occur may be used to differentiate backgrounds (Table 3). In this case, plant bug and *Heliothis* damage was high. Insect control in this nursery was purposely delayed until after fruiting was underway. Under these conditions some backgrounds responded to control better than others.

Another example of differentiating backgrounds with yield data is provided by an all glandless test conducted by Rogers Delinted Cottonseed Company at Waco, Texas (Table 4). The test was located in an area planted to all glandless cottons and plant bugs were the major insect problem. An undesignated California Acala glandless strain was severely damaged. This illustrates background differences in response to adversities and suggests that Rogers is developing improved glandless backgrounds with insect resistance.

Differential performances of variety backgrounds are often credited to environmental adaptation. Yet, good levels of multi-adversity resistance will neutralize many interactions of differential performance over environments (Bird, 1973). Degrees of resistance to some diseases and insects have been added to most variety backgrounds (Bird, 1973). Harlan (1976), in discussing disease resistance pointed out a statement credited to Van der Plank, indicating that "plant breeders and pathologists are busy patching their mistakes and bragging about how big the patches are." A few years from now, will the same apply to breeders, pathologists and entomologists? Will we use the approach of patching old varieties by adding glandlessness and disease and insect resistance? Or, will we use the approach of developing new backgrounds in which glandlessness and disease and insect resistance are primary traits?

TABLE 3. Performance of glanded cultivars of cotton in the 1977 Brazos Valley glandless nursery

Cultivar	Lint yield per acre
	lbs.
G&P 3755	273a[a]
Tamcot SP21S	264ab
Stoneville 731N	241abc
McNair 3035	183abcd
Tamcot CAMD-E	171abcd
Tamcot SP37H	152 bcde
G&P 3774	144 cde
Lyman-76 (glandless)	141 cde
Stoneville 213	134 cdef
Lockett 77	117 def
Paymaster 303	38 ef
Paymaster 266	19 f
Average	156

[a]Averages followed by the same letter are equal according to Duncan's test for the 5% probability level.

TABLE 4. Performance of Rogers Delinted Cottonseed Company glandless cotton cultivars in an area where only glandless cottons are produced, Waco, Texas, 1977

Cultivar	Lint yield per acre
	lbs.
Strain 440	369a[a]
Strain 444	356a
Strain 439	313a
Strain 438	311a
RDC-10	308a
Glandless Calif. Ac.	113 b
Average	295

[a]Averages followed by the same letter are equal according to Duncan's test for the 5% probability level.

GENETIC IMPROVEMENT OF BACKGROUND FOR DISEASE AND INSECT RESISTANCE

The Texas A&M multi-adversity resistance (TAM-MAR) genetic improvement system is using new concepts and procedures for developing new germplasm in cotton. Concepts, procedures and progress in the program have been reported elsewhere (Bird, 1973; Bird, 1975; Bird, 1977; Bird et al., 1977). The system uses indirect selection to intensify dosage and to obtain more favorable combinations of survival, fitness (Grant, 1975) and resistance genes. We refer to them collectively as MAR genes. The indirect selection makes it possible to ignore major gene effects which in many cases mask the expression of important minor genes. The TAM-MAR system systematically develops genotypes having increased levels of MAR genes and simultaneous improvement for yield potential and earliness occurs. In other words, the TAM-MAR system is effective in developing new backgrounds with genes for adversity resistance and in these backgrounds the expression of resistances is effective for controlling adversities. Such a system of genetic improvement should be effective in developing disease and insect resistant glandless cottons.

Several families or backgrounds of germplasm have been developed in the TAM-MAR program (Table 5). The older families were used to develop newer normal leaf-bract families. Recent emphasis has been on developing okra leaf and frego bract counterparts and is now shifting to development of glandless counterparts.

Disease Resistance

Primary emphasis within the TAM-MAR program has always been on disease resistance. The relative level of resistances to major and minor diseases achieved in the germplasm are given in Table 6. Improved levels of resistance to major seedling disease pathogens as well as the pathogen causing *Phymatotrichum* root rot has been recently found in TAM-MAR cultivars.

We are depending on morphological traits for controlling boll rot, but the presence of physiological resistance cannot be ruled out. For the other diseases both physiological and a mechanism involving a protective type resistance are functioning. Our data suggests that the level of resistances to diseases will improve as further progress is made in the TAM-MAR program and that the higher levels can be established in glandless backgrounds.

Insect Resistance

Information on insect resistance was obtained from two 1977 tests. John Benedict's test (at the Perry Foundation west of Corpus Christi, Texas) compared glanded and glandless TAM-MAR types and glandless strains from other programs in the presence of boll weevils, *Heliothis* and plant bugs. A Brazos Valley test (at the A&M University farm west of College Station, Texas) gave performance data in the absence of boll weevils and under high populations of plant bugs and *Heliothis*. Average yields of TAM-MAR cultivars over four locations (Refugio, San Patricio, Nueces and Jim Wells Counties) in the Corpus Christi area are used to illustrate performance under grower management.

The Perry Foundation test was a randomized block (treated and untreated) experiment (Table 7). SP37-76C was used as the reference check as it represents Tamcot SP37 which is grown on most of the acreage in the Corpus Christi

(Continued on page 133.)

TABLE 5. TAM-MAR families or backgrounds and progressive development of okra leaf, frego bract and glandless counterparts

Normal leaf - bract		Okra leaf and frego bract	Glandless[a]
Older base families	Newer base families		
SP21[b]	CAMD-S[b] Blank-SU[bc]	ORS[b]	GORS[b]
SP37	CAMD-H CAMD-E	ORH	GORH GN-1
Lewis (LE)	Blank-1[bc]	ORHLE	GN-2
Bonham (BO)		ORHBO ORSBO[b]	Lyman
	MAR[d]	ORMAR-H ORMAR-S[b]	
	LEBO	ORLEBO	

[a]OR indicates okra leaf and frego bract type, and N indicates nectariless.

[b]Glabrous leaves and stems.

[c]Resistant to Southwestern cotton rust.

[d]MAR was developed from crossing CAMD and Lewis.

TABLE 6. Relative level of resistances to major and minor diseases within the TAM-MAR germplasm pool

Disease	Susceptible — Partial resistance — Resistant — High resistance 10 20 30 40 50 60 70 80 90 100
Bacterial blight (18 known races)	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Seedling disease	
Rhizoctonia solani	XXXXXXXXXXXXXXXXXXXXXXXXX
Thielaviopsis basicola	XXXXXXXXXXXXX
Pythium spp.	XXXXXXXXXXXXX
Fusarium wilt root-knot nematode	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Verticillium wilt	XXXXXXXXXXXXXXXXXXXXX
Seed deterioration	XXXXXXXXXXXXXXXXX
Seed rot	XXXXXXXXXXXXXXXXX
Phymatotrichum root rot	XXXXXXXXXXXXX
Reniform nematode	XXXXX ?
Boll rot[a]	? ?
Fungus leaf spots	
Southwestern cotton rust	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Alternaria solani	XXXXXXXXXXXXXXXXX
Ascochyta gossypii	XXXXXXXXXXXXXXXXX

[a]Dependent on morphological characters.

TABLE 7. Relative performance of glanded and glandless cotton cultivars which were and were not protected[a] with insecticides from damage by insects (Data by John Benedict)

Cultivars and their traits[b]	Averages for untreated and difference due to treatment[c]					
	Lint yield per acre		Boll weevil damage[d]		Heliothis damage[d]	
	Un-treated	Difference due to treatment	Un-treated	Difference due to treatment	Un-treated	Difference due to treatment
	lbs.	lbs.				
CAMD-E,G'ded,normal,hairy	478*	+ 34	39*	-13**	6	+ 9
ORMAR-SB,G'ded,ok,frego,sm	476	+166**	17*	0	4	+ 4
GORH-B,G'less,ok,frego,hairy	398	+130	25*	-19**	6	+ 1
SP37-76C,G'ded,normal,hairy	370 ck.	+ 53	107 ck.	-75**	7 ck.	+ 5
GORS-76C,G'less,ok,frego,sm	305	+ 76	26*	-12**	8	+ 2
Lyman-76,G'less,normal,hairy	292	+114	79	-60**	7	+16**
CA2190-76BG,Lubb.,G'less,norm.,hairy	203*	+172**	101	-74**	25*	+ 2
G8160 Calif. Ac.,G'less,norm.,hairy	172*	- 24	53*	-32**	8	+ 4
CA2150-76BG,Lubb.,G'less,norm.,hairy	116*	+113	101	-75**	12	- 4

[a]Planted March 18, 1977. All plots were treated with Bidrin May 18. The treated subplots received Guthion May 13 and May 18; Toxophene plus Methyl Parathion June 9; and Azodrin plus Methyl Parathion July 13.

[b]G'ded = glanded, G'less = glandless, normal = leaves and bracts, hairy = leaves and stems, sm = smooth leaves and stems, ok = okra leaf, frego = frego bract.

[c]Comparing among untreated cultivars the averages marked (*) differ from the check SP37-76C at the 5% probability level. Comparing within cultivars for untreated and treated the differences marked (**) are significant at the 5% probability level.

[d]Boll weevil egg punctured squares and *Heliothis* damaged squares per two meters of row.

area. Among untreated cultivars CAMD-E had a higher yield and glandless CA2190, G8160 and CA2150 had lower yields in comparison with SP37-76C. The yields for the TAM-MAR glandless types did not differ from SP37-76C. With the exception of G8160 all cultivars tended to have higher yields when treated. Only glanded ORMAR-SB (known to be sensitive to plant bugs) and CA2190 had significant increases in yield. The difference for ORMAR-SB may be attributed to the continual presence of plant bugs, whereas the difference for CA2190 may be due to the significant Heliothis damage in the untreated plots. Yield differences reflect the improved adversity background of CAMD-E in contrast to the unimproved adversity backgrounds of the CA and G8160 cultivars. The backgrounds for ORMAR-SB, GORH-B, SP37-76C, GORS and Lyman are not as improved as the CAMD-E background. Yield differences certainly cannot be attributed to the presence or absence of genes for glandlessness.

Numbers of boll weevil egg punctured squares were less for glanded CAMD-E and ORMAR-SB; and glandless GORH-B, GORS and G8160 compared to SP37-76C. The lower damage in the normal glanded CAMD-E and normal glandless G8160 suggest a nonpreference type resistance, whereas the lower damage on GORH-B and GORS could be due to the frego bract effect. The lowest damage was found for ORMAR-SB with no change due to treatment. Additiveness of the frego bract effect with a degree of nonpreference resistance is suggested. Less damage in ORMAR-SB from boll weevils in comparison with other okra leaf, frego bract and smooth (ORS) TAM-MAR strains has been noted before (Bird et al., 1977). A reduced damage from boll weevils has been previously noted in California Acala types (Jenkins et al., 1966). With the exception of ORMAR-SB, all cultivars had less boll weevil damage in the treated plots.

Infestations of Heliothis were below normal and therefore, Heliothis damaged squares were relatively low. Among untreated cultivars only glandless CA2190 had an increase in comparison with SP37-76C. With one exception, CA2150, damage was higher for all cultivars in the treated plots but only glandless Lyman had a significant increase. Four glandless and three glanded entries responded essentially the same to Heliothis damage.

Thus, the Perry Foundation test situation reflects major boll weevil damage and minor damage from plant bugs and Heliothis. Differences in yield and damage cannot be attributed solely to glanded-glandless differences. Differences are related more to backgrounds in relation to improvement for adversity resistance. The TAM-MAR germplasm as a whole encompasses both the frego bract effect and a nonpreference type resistance for the boll weevil.

Management of the Brazos Valley test included use of a herbicide, 300 pounds 16-20-0 fertilizer, no irrigation and no insecticides. The yield results provide significant information on the improvement of TAM-MAR backgrounds for adversity resistance (Table 8). The cultivars are grouped so that relative progress within glanded, normal leaf-bract types; within glanded, okra leaf and frego bract types; and within glandless types may be more obvious. The cultivars are arrayed high to low within each group according to their yield in the Brazos Valley test.

The Corpus Christi data are given to provide a reference to the yield potential under grower management. The yield for Stoneville 213, an entry in the 4 location test, is given at the bottom of each group to provide a point of reference. Under grower management the glanded normal types were superior to Stoneville 213. The okra leaf and frego bract ORMAR-SB, ORMAR-SA and ORBO cultivars were superior to Stoneville 213. The remainder of the OR and the glandless cultivars produced the same as Stoneville 213. Thus, all the TAM-

TABLE 8. Relative yield of 1976 TAM-MAR cotton cultivars in a 1977 Brazos Valley test under minimum moisture-fertilizer management and the use of no insecticides; and the yield average of four tests, under grower management, in the Corpus Christi, Texas area

Glanded normal leaf-bract cultivars	Lint yield per acre Brazos Valley[a]	Lint yield per acre Corpus Christi	Glanded okra leaf fregobract cultivars	Lint yield per acre Brazos Valley[a]	Lint yield per acre Corpus Christi	Glandless cultivars[c]	Lint yield per acre Brazos Valley[a]	Lint yield per acre Corpus Christi
	lbs.	lbs.		lbs.	lbs.		lbs.	lbs.
CAMD-E	331a[b]	703a-c[b]						
CAMD-H	326a	653 b-e						
SP37-76	268a	688 b-d						
SP21-76*	244ab	679 b-d						
CAMD-S *	241a-f	832a	ORMAR-SB*	208a-h	726ab			
MAR-76	209a-h	714a-c	DORS *	188 b-h	545 e-f			
Blank-1*	156 c-j	768ab	ORMAR-SA*	170 b-j	712a-c			
Stoneville	213 ck.	456 fg	ORS-76 *	165 b-j	——			
			ORBO	147 d-j	702a-c	Lyman	131 e-k	542 ef
			ORH-B	120 e-k	581 c-f	GORH-B	88 h-k	557 d-f
			ORH-A	113 f-k	587 c-f	GORS-76*	44 j-k	514 fg
			ORLE	112 f-k	667 b-e	GORH-A	21 k	406 g
			Stoneville	213 ck.	456 fg	Stoneville	213 ck.	456 fg

*Cultivar has glabrous stems and leaves.

[a]Damage from plant bugs and Heliothis was severe.

[b]Averages followed by the same letter are equal according to Duncan's test for the 5% probability level.

[c]Lyman has normal leaves and bracts and the others are okra leaf and frego bract glandless types.

TABLE 9. Relative level of resistance to insects within the TAM-MAR germplasm pool

Insect	Susceptible		Partial resistance			Resistant			High resistance	
	10	20	30	40	50	60	70	80	90	100
Thrip	XXXXXXXXXXXXXXXXX									
Fleahopper[c]	XXXXXXXXXXXXXXXXX									
Lygus spp.[c]	XXX ?									
Boll weevil[a]	XXXXXXXXXXXXX									
Heliothis spp.[bc]	XXXXXXXXX									
Pink bollworm[bc]	?									

[a]Additional aid provided by frego bract.

[b]Additional aid provided by glabrous leaves and stems.

[c]Additional aid provided by nectariless.

MAR cultivars gave a respectable performance under grower management. However, several OR and the glandless cultivars were inferior to the best TAM-MAR types. This indicates that further improvements must be made in background for OR and glandless cultivars.

Persistent uncontrolled plant bugs and *Heliothis* populations in the Brazos Valley test caused severe damage with the former probably being the major adversity. In an adjacent portion of the Brazos Valley nursery the plant bugs were brought under control after flowering began. Thereafter, the emphasis was on control of *Heliothis*. Under this management CAMD-S produced 415 and CAMD-E 253 pounds lint per acre.

The top yield in both the untreated Perry Foundation and Brazos Valley tests was produced by CAMD-E. However, the severe damage in the Brazos Valley test indicates a partial deficiency for plant bug resistance in CAMD-E and other normal types. The greatest deficiencies were in several OR and the glandless cultivars. Sensitivity to plant bugs is a known problem for other glandless backgrounds (Benedict et al., 1977). There is a trend in improvement for resistance to plant bugs and *Heliothis* within the glanded, normal leaf-bract, and the glanded, okra leaf and frego bract TAM-MAR cultivars (Table 8). The glabrous cultivars tend to group towards the bottom of the yield array for glanded normal types while the opposite is true for the glanded, okra leaf and frego bract cultivars. No real trend for improvement in plant bug resistance is indicated for the glandless types.

The relative level of resistance to specific insects in the TAM-MAR germplasm are illustrated in Table 9. The progress trends indicate that the levels may be increased in glanded as well as glandless types.

TABLE 10. Relative performance ratings of older 1976 TAM-MAR cotton cultivars and newer 1977 types showing the potential new progress that has been made in developing disease and insect resistant glandless cottons

Glanded normal leaf-bract cultivar	Average performance rating[a]		Glanded okra leaf frego bract cultivar	Average performance rating[a]		Glandless cultivar[b]	Average performance rating[a]	
	Mature	Total		Mature	Total		Mature	Total
1977								
CAMD-SE*	1.8	2.7	1977					
Blank-SU*	2.2	2.8	ORMAR-S-3*	2.0	2.7	1977		
CAMD-HE	2.4	2.9	ORSBO *	2.5	2.7	GN	2.3	2.8
LEBO	2.3	3.0	ORHLE	2.7	2.7			
1976			ORS *	2.4	2.8	GNORS-Red-1*	2.4	2.5
CAMD-E	2.1	2.7	ORMAR-H	2.5	2.8			
CAMD-H	2.0	2.8	ORHBO	2.6	2.8			
SP37	2.8	3.1	ORH	2.7	2.9			
SP21	2.9	3.2	1976					
CAMD-S *	2.6	3.0	ORMAR-SB *	2.5	2.9			
MAR	2.0	2.8	DORS *	3.1	3.3	GORH	3.0	3.3
Blank-1*	2.4	3.2	ORMAR-SA *	3.1	3.5	1976		
			ORS *	3.4	3.5	Lyman	2.7	3.3
			ORBO	2.8	3.3	GORH-B	3.6	3.6
			ORH-B	2.6	2.9	GORS *	3.6	3.9
			ORH-A	2.9	3.1	GORH-A	3.9	4.0
			ORLE	3.1	3.4			

*Glabrous.

[a]See footnote a, TABLE 1. Average ratings for the mature crop and the total which reflects early, mid and mature plant development periods are given. The averages are over eleven Texas locations as follows: 2 at Weslaco, 2 at Corpus Christi, 2 at College Station and one each at Temple, McGregor, Chillicothe, Lubbock and El Paso.

[b]GN and Lyman are normal leaf-bract types and the others are okra leaf and frego bract. The presence of "N" in the designation indicates nectariless.

Further Progress

In 1977 some 140 new and older TAM-MAR strains were evaluated in 11 nurseries. Performance ratings were made once at El Paso, twice at Lubbock and 4 times at each of the other locations (Table 10). The mature crop ratings are averages of 11 observations. The total rating was based on 44 observations made periodically during the growing season. The older 1976 cultivars are grouped and arrayed in the same manner used in Table 8. The newer 1977 cultivars are arrayed above the dashed line for each group. In comparison with the 1976 cultivars the newer glanded normal types suggest some further improvement has been made. Performance ratings for CAMD-SE (a glabrous CAMD-E) and Blank-SU (a glabrous CAMD type having Southwestern cotton rust resistance) indicate improvement over 1976 counterparts. Substantial progress has been made within the glanded okra leaf and frego bract group (Note: ORMAR-S-3 vs. ORMAR-SB, ORSBO and ORHBO vs. ORBO, ORS-77 vs. ORS-76 and ORHLE-77 vs. ORLE).

Many of the newer glandless strains were eliminated due to performances in the presence of plant bugs in the Brazos Valley and Temple, Texas, nurseries. However, the performance of GN-77 (a nectariless CAMD type) material was striking and probably represents a real breakthrough for improving backgrounds for glandlessness. The GNORS-Red-1 (gl_1 gene only) is strictly a parental type and shows promise in this respect. The 1977 GORH has the potential of being better than GORH-B-76.

We expect considerable improvement to come from hybrid pools utilizing GN-77, GNORS-Red-1, ORMAR-S-3, ORSBO, CAMD-SE and Blank-SU as parents. The crosses will also distribute the nectariless trait into more of the TAM-MAR backgrounds. Highly improved multi-adversity resistant glandless backgrounds should come from these crosses.

New glandless progenies were evaluated in the 1977 Brazos Valley nursery (Table 11). The high populations of plant bugs were purposely not controlled until after flowering was underway. Low early season ratings indicate a better performance in the presence of plant bugs. A low late season rating indicates a better performance in the presence of *Heliothis* as well as a good total performance. Several of the new glandless progenies have the potential of improvement for multi-adversity resistance.

Earliness and Plant Types

Earliness or fast rates of fruit set and boll maturation is recognized as a key trait for a pseudo-resistance to many diseases and insects. The TAM-MAR germplasm is now recognized as having an earliness that is superior to other type cottons (Bird, 1977). It is not unusual for TAM-MAR cultivars to mature 500 to 600 pounds lint per acre within 120 to 130 days from planting. Mature yields within such a relatively short period of time are usually set and safe before boll weevil and *Heliothis* populations increase enough to cause serious damage. Much of the yield is also set and safe before serious damage occurs from *Phymatotrichum* root rot. *Verticillium* wilt and boll rots. The TAM-MAR selection procedure gains simultaneous improvement for earliness along with selection for multi-adversity resistance. The TAM-MAR okra leaf and frego bract cultivars have a rate of flowering about twice that of the TAM-MAR normal leaf types. Use of the faster fruiting trait will be more effective as the okra leaf and frego bract types are improved. Consequently, no problems exist in developing glandless types which are as early or earlier than current TAM-MAR glanded cultivars.

TABLE 11. Performance ratings for new glandless TAM-MAR progenies and checks in the 1977 Brazos Valley nursery

Progeny designation			Average performance rating[a] Early season	Late season
111R	ORS-59 x Ly-18	GORS	2.5	2.5
45G	H^4-14 x Ly-18	GS	2.5	2.5
48G	GN-2 x Blank-1	GNS	2.5	2.5
28M	278R	GNORH	2.5	2.5
	G&P 3755	ck.	3.0	3.0
	Lyman	ck.	3.0	3.0
34B	ORS-59 x ORGN	GNORS	3.5	2.0
	CAMD-E	ck.	3.5	3.0
45A	ORS-59 x GN-2	GNORS	4.0	2.5
39A	ORS-59 x GN-2	GNORS	4.0	3.0

[a]See footnote a, TABLE 1.

Emphasis during recent years in the TAM-MAR program has been for plant types usable in short season management systems. However, plant types in the TAM-MAR system range from dwarf close fruiting ones such as Bonham to taller open fruiting ones such as Lewis. Plans are to develop glandless backgrounds within a full range of plant types.

Fiber Traits

Emphasis in selecting to change fiber traits within the TAM-MAR program is not practiced. The elimination of progenies having fiber lengths less than one inch, strengths on the low side for the group being evaluated and micronaire values above 5.0 is practiced. The main objective has been to maintain as much variability as possible for fiber traits in the TAM-MAR germplasm. The range of differences for the current strains are as follows:

Length		Strength	
50 SL	.46 - .60	T_1	17.4 - 22.5
2.5 SL	.98 - 1.21	E_1	5.3 - 8.9
Uniformity	45 - 51	Micronaire	3.4 - 5.7

GENETIC VARIABILITY

Improvement of a crop depends on the amount of genetic variability generated within a germplasm pool and the success in obtaining and identifying gene recombinations for the desired expression of many traits. The TAM-MAR germplasm now has genetic variability for resistance to most of the major and many minor adversities in production that plague cotton producers. The improvement procedure, utilizing genetic interrelationship information, has been successful in developing cultivars having desired traits. It is now apparent that the trends of progress accomplished in glanded, normal leaf bract, and glanded, okra leaf and frego bract groups can be repeated in devel-

oping glandless cottons. The morphological traits which have been found to aid in controlling diseases and insects are being utilized successfully in the new types. The end products are genetic backgrounds which effectively utilize survival, fitness and resistance genes in cotton. In the future, these backgrounds containing the glandless character will be much more important to the cotton industry in comparison with glanded cottons.

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DISCUSSION

R. J. MIRAVALLE Dr. Bird, how do you go after this management problem? How do you determine your testing and proper management procedures for new strains of cotton? I am following up the question that I asked before of Dr. Ridgway?

L. S. BIRD Well, of course, we do not conduct management experiments. The MAR strains are used by others in their pest management experiments. Some of these data have been left for other talks. Now, John Benedict, for example, is one who is following through with this material. Some of the data given in our talk represents the kind that John is collecting. John is virtually studying all of our material. You must have preliminary understanding in order to set up larger management tests.

I think some of these type data were what John collected this past year and represent a kind of pest management research . He had some larger scale experiments but the results were not given here. These results indicate some of the things we can expect under a treatment or a non-treatment situation. We will not do this ourselves, but this will be done with other people in their research efforts. Does that answer your question?

J. H. BENEDICT One of the points that Luther brought up, and I just might discuss it real quickly to make sure that it was understood by all of us, is that incorporating the glandless character into these favorable resistant backgrounds (that is, various resistant characters are incorporated into these backgrounds) we were able to produce cotton which had yields equal to or greater than our standard variety which was SP 37 in this case and we also had a suppressed amount of insect damage. In regard to Dr. Miravalle's question where he asked about pest management programs and so forth, what we are trying to do now is to evaluate the advantages and disadvantages, i.e., strengths and weaknesses, of some of these glandless characters in varous backgrounds so that we can develop a pest management program that they can be incorporated into. This would be a whole new ball game. We have got to work on different pests, different thresholds and so forth. I have recently submitted to Cotton Incorporated a proposal to help fund this type of work. It means going to large plots, and you have got to get grower cooperation. You have to increase seed, all of which costs money. If any of you folks are willing to help out in this type of thing, I need a little incentive. I would appreciate it.

Recently, I suggested to Don Anderson (when he proposed to us that they were going to develop a Texas pest management program) that possibly we might work together with this program to evaluate on farmers' property some of these various glandless materials. Don assured me there would be a lot of very cooperative farmers that would not need any kind of incentive other than a pat on the back to cooperate in this type of a program. I, myself, felt that the farmer would like a little insurance that we would be able to make up the difference in yield should there be one.

GROWERS' ASSESSMENTS OF PEST MANAGEMENT FOR GLANDLESS COTTON

Statement by Weldon Gregg

My first experience with growing glandless cotton was in 1961. In that season and the two following, it was grown on only a few rows in a nursery plot of glanded cotton - which is admittedly the most vulnerable condition possible, in the event of a pest outbreak. During these three years, we never noticed any unusual amount of pest activity or damage on the glandless plants. In 1964, we began growing glandless cotton on a field scale. During 1964 and the next four years, we did not notice any widespread economic damage from insects to cotton in our community, either in the glanded cotton or the glandless.

In the summer of 1969, on the date of the astronauts' launch for the first human landing on the moon - July 17 - a period of cool, cloudy weather began at Plainview and continued for several weeks. This apparently created ideal conditions for the cotton bollworm's reproductive cycle, and by the end of August there was a massive bollworm infestation throughout the north part of Hale County. About the first of September, Ollie Liner, Hale County Extension Agent, called a meeting to discuss this problem. The meeting was attended by nearly one hundred farmers. Mr. Liner stated that never before in his career had he seen as many bollworm eggs as were present generally in the Hale County cotton fields, adding, "Of course, I don't know how many of them will hatch." By the time of that meeting, it was too late to control bollworm in most fields, except those where a control program had already begun. There were only a few hundred acres of glandless cotton in the Plainview area that year, so this infestation clearly involved glanded cotton. Our glandless cotton suffered massive damage, and as far as we could determine, the glanded cotton grown that year under the same conditions suffered equally massive damage. The experience that year emphasized the need for a good pest management program in any kind of cotton, but it did not indicate any real difference in the pest problems of glanded compared with glandless cotton.

During the next few years after 1969, we again noticed no unusual amount of pest damage in cotton near Plainview. Then on June 22, 1975, a tremendous hailstorm moved across the northern part of Hale County. In some fields damage was almost total and the land was replanted in soybeans. However, in most fields the cotton began making new growth immediately after the storm, so the producers decided to leave it. This cotton was delayed three weeks in maturity, and an unusually wet July apparently set up a favorable bollworm reproduction cycle that found this cotton in a tender and lush stage of growth at the peak of the bollworm hatch. When

the insects were not controlled, damage to these fields resulted in almost total loss. Most such fields were appraised as disasters by the county ASC office; some farmers elected to harvest the cotton anyway, with yields in most cases ranging from 25 to 75 pounds of lint per acre. Once again, the amount of damage appeared to be similar in glanded and glandless fields, with no significant difference in the type of pest management needed for either type of cotton.

The season just concluded - 1977 - was another year in which bollworms were a serious problem in Hale County. During this year, for the first time, we observed some difference in the level of infestation of glanded and glandless fields in similar locations. The general severity of infestation is shown by a quotation from Greg Cronholm, county extension entomologist. He conducted a demonstration pest management program in western Hale County, involving 55 producers. One thousand and sixty-four acres of cotton were included in this program, and Mr. Cronholm states in his report:

> "Cotton bollworms increased to high numbers by August 25. Beneficial insects were plentiful and provided assistance in reducing bollworm numbers. Most cotton in the program required treatment for bollworms during September. . . . Cotton bollworms presented major problems for cotton producers in the program area. Only 105 acres did not require treatment for cotton bollworms."

On our farms at Plainview this year, 1977, with all glandless cotton, we did not find it necessary to spray for bollworms, and no economic damage was observed from worms. In regard to one of these farms, it is interesting to note that the three fields of cotton in close proximity to this farm--all glanded cotton--were sprayed for bollworms. On two farms the glanded cotton was immediately adjacent to this glandless plot, and the third farm was approximately three-quarters of a mile distant.

Also, one producer at Plainview with over 1,000 acres of cotton--all of it glandless--did not spray any of his acreage this year, and likewise reported no economic loss. This acreage was divided among six tracts with a separation of about seven miles between the most distant tracts, and was in an area where some very heavy spraying for bollworm took place.

On the farm where I live, I was anticipating serious bollworm infestations this year because of proximity to corn. Corn was directly adjacent to the cotton on two sides, and on a third side the corn was only a quarter-mile distant. I was anticipating bollworm infestations not because the cotton was glandless - I would also have anticipated an infestation if the cotton were glanded and grown in such proximity to corn. Furthermore, the planting dates for the corn extended from April 5 to June 4, providing the bollworm with a host crop for a very long period of time.

However, when the period of bollworm activity began, I was surprised to find only a few small worms on the dozen rows

immediately adjacent to the corn, and in the remainder of the field it was hard to find a single bollworm. I eventually decided not to spray this field, and as I have already stated, we did not notice any economic damage from bollworms during the remainder of the growing season or at the time of harvest.

My feeling, based on these observations for fifteen years, is that there is little difference in the pest management requirements of glanded and glandless cotton. Cotton has been susceptible to the multitude of pests since it was first cultivated and I cannot see that glandless varieties have either added to or diminished that susceptibility. I emphasize that I speak only of the High Plains area, as this is the only area where I have any direct experience. In other parts of the Cotton Belt, conditions may well be different.

I called a farmer shortly before I left to attend this meeting - because I knew that he had a sizeable acreage in both glanded and glandless cotton. He said that he had noticed no particular difference in 1977 so far as varieties were concerned - he had to spray some of his glandless cotton, some he did not spray - and the same was true of his glanded. He then remarked that ever since he had been growing cotton that he had noticed that regardless of variety, any cotton that tended to be lush, tender or rank during the bollworm infestation period was susceptible to attack, while cotton that was maturing and in a less succulent stage of growth would usually escape serious damage. It does appear that on the High Plains, at least, the interaction of the plant with its environment is the most important single factor to be considered in pest management.

Statement by Edward N. Stiver

Insect infestation in cotton, both high and low gossypol varieties, has been observed and controlled by identical methods by our organization for the past 15 or so years. Effective early season control measures for the thrip and fleahopper must be maintained, plus at least one weevil application, if weevils are present. A bollworm program in our area is most difficult and had best be avoided by allowing the beneficial insect population to reach a level sufficient to control the bollworm complex.

I am referring to the low gossypol varieties with which I have worked and developed. We have mostly Texas breeding stock, high in disease tolerance, and we are now ready with new lines of insect tolerant materials, especially to the Hemiptera. Our lines have shown good production levels from Louisiana to El Paso.

This question of insects in low gossypol cotton was studied by the USDA-ARS, at the Cotton Insect Laboratory, Waco, Texas, about 1966. Mr. C. B. Cowan conducted the study which was initiated by Dr. Sloan Jones, Head, Cotton Insect Investigations, USDA-ARS, Washington, D.C. Their finding of "no significant difference" assured us when we first initiated a breeding program that

we were encountering nothing new. Further, a 1975 report by Mr. Don Rummel of the Lubbock Experiment Station, made in Lubbock to a Cotton Breeder's group, sponsored by The National Cottonseed Crusher's Association, Mr. Dalton Gandy in charge, further substantiated that no economic differences existed. As recent as the Spring of 1977 at the meeting of the Texas Certified Seed Producers, Inc., Dr. Luther Bird presented similar data.

In closing, the Rogers Company, speaking from our own observations in producing low gossypol varieties, has not had any different insect problems from our production fields of high gossypol varieties. This also includes seed storage, both in bulk and bag, insects and rodents included.

Statement by Howard A. Wuertz

As a grower receiving most of my income from cotton, I am vitally interested in glandless cotton and all and any other new developments and practices that would increase the value of cotton and its byproducts and add to grower income.

It would be wonderful if all our cottonseed could be economically produced from gossypol-free varieties with the additional markets that would then be available.

As far as I have been able to determine, glandless cotton has not been produced commercially in Arizona. However, test plantings have been grown in Arizona and California off-and-on for the past fifteen years or so.

Based on these limited tests, it appears that glandless cotton may have some problems for Arizona growers. First, some insects seem to prefer this type of cotton. Some of these are the grape colaspis beetle, striped and ash-gray blister beetles, cotton leaf worm, cucumber beetle, pill bugs, lygus, bollworm, budworm, beet army worm and perhaps others. One laboratory rearing test with bollworm, budworm, and beet army worm larvae revealed that the larvae reared on glandless lines weighed 2 to 3 times as much as those reared on glanded varieties. Removal of gossypol and possibly other growth inhibitors was thought responsible for the highly significant increase in weight. It was also noted that the bollworm moth had a preference for egg laying on some glandless types.

It would appear that unless this seeming preference for glandless cotton by some insects can be eliminated, commercial production may be limited to areas such as the Texas High Plains where insects are not so great a problem. Otherwise, the increased use of required insecticides may not be economically feasible.

The other problem observed in Arizona test plantings is that the glandless lines we have planted seem to present a rodent problem. Researchers at the Arizona Cotton Research Center Farm found that rabbits (particularly jackrabbits) would find unprotected test plantings and eat the plants to the ground level--this happened even when the test plantings were purposely hidden in

very small plots (some only a few plants) in the center of large plantings of glanded cotton. In addition, it was found that field mice have a great appetite for glandless cottonseed. The mice would begin to harvest the seedcotton as soon as the bolls opened.

The rabbit problem may not be a problem in all areas, but many of our production areas are adjacent to desert areas where rabbits abound. Our research center farm is within the city limits of Phoenix and since it was a problem there, undoubtedly it would be a problem in most areas in Arizona--particularly in years when rabbit populations are high. Researchers also were surprised with the extent of the field mouse damage. However, it must be pointed out that with large plantings these problems may not be so significant as indicated. Perhaps the experience with the large plantings in Texas has the answer to these problems.

There would appear to be several other problems that would need to be solved before producers in Arizona would extensively plant glandless cotton.

First, glandless varieties that would yield comparable quantities and qualities at about the same production costs would have to be developed.

Secondly, ginners and oil millers should be able and willing to handle the glandless seed. It would appear that to be effective, an entire gin production area should be shifted to glandless cotton at one time. I doubt that any Arizona ginner would want to provide two separate systems for handling seed at his gin.

The same dual handling system problem may be experienced at the oil mill. In addition, I understand considerable costs are required to equip oil mills to meet the Food and Drug Administration requirements for using cottonseed meal for human consumption. Perhaps these matters have been or will be covered in detail at this seminar.

If solutions to these, and perhaps other unforeseen problems can be worked out, I'm sure Arizona cotton growers would switch to glandless varieties.

THE NEED FOR GLANDLESS PURITY

By Richard A. Phelps

Purity is defined as the quality or condition of being pure, or free from impurities or foreign matter. In this discussion we assume that all foreign matter in cottonseed has been removed from glandless cottonseed and we are dealing only with the impurity of glanded cottonseed.

In this discussion, we also assume that all truly glandless cottonseed is free of gossypol and that all glanded cottonseed contains gossypol and other pigments in the pigment glands. It therefore follows that any study which reports a certain level of gossypol in glandless seed or glandless flour, or glandless concentrate or glandless isolate, was probably not a study of glandless cottonseed products. It was more likely a study of a blend of glandless and glanded cottonseed or products made from such a blend. Unfortunately, the food and feed research literature may be contaminated with data from such glanded - glandless blends which results in an unfair portrayal of the true value and potential of glandless cottonseed.

How much contamination with glanded cottonseed can occur before glandless cottonseed products are adversely affected by the pigment glands in glanded cottonseed? Peter Wan and his associates at the Food Protein R&D Center of Texas A&M reported pertinent data at the June 1977 Institute of Food Technologists Meeting in Philadelphia. They concluded that the maximum tolerable level of total gossypol in cottonseed flour is about 0.03 percent (300 ppm), or the equivalent of contamination with 2 to 3 percent glanded cottonseed. Incidentally, Wan and his associates in this very informative report also concluded that gland-free cottonseed products should be considered as gossypol free.

The other speakers on this panel will undoubtedly focus on the possibility of restricting contamination of glandless seed to a total of about 2 percent glanded seed after the seedsmen, insects, growers, ginners and oil millers have all played their role in the production and processing of glandless cottonseed products. I will have to defer to others in assessing how realistic it is to expect contamination to be held to 2 percent glanded cottonseed. Certainly we all can agree that we need a realistic, economically feasible program which will insure a maximum percentage of glandless cottonseed.

Only by making it economically unattractive to contaminate glandless cottonseed with glanded seed can we insure that cottonseed protein will achieve its true potential.

MAINTAINING VARIETAL PURITY OF PLANTING SEED

By Othel M. Neely

In trying to develop my thoughts for this presentation, I recalled a statement oftentimes made by a late friend of my father. He made the statement to describe the process of living and learning. The statement was, "We are going through life backwards; we can see where we have been, but we don't know where we are going." This fairly accurately describes seedsmen as they try to deal with the production of glandless cotton planting seed. Unfortunately, our vision into the past reveals primarily experiences with producing quality cotton planting seed of varieties which I'll refer to as standard varieties.

Some seedsmen have been increasing glandless cotton planting seed for several years. Unfortunately, they went into production backwards. They knew where they had been in producing seed of the standard varieties, but they could not see where they were going in producing seed of glandless varieties. On the surface, there appeared to be minimum problems in increasing seed of glandless varieties, but experience and time have revealed otherwise.

What are some of the problems associated with this new characteristic? First, one must understand that cottonseed production is a secondary product for the cotton farmer and that seed production, in general, must be in areas where the crop can be grown the best and the cheapest. Simply stated, it is impractical for a cotton planting seed production block to be on land not suited for cotton lint production and in areas long distances away from gins and other equipment necessary for the production, harvesting, and processing of cotton lint and cottonseed.

The immobility of producing cotton planting seed created some new problems for seedsmen marketing seed of glandless varieties. First, one of the problems is cross-pollination with standard varieties by normal insect population. This is especially a problem in the cotton production areas not requiring insect control with chemicals. Chemical control of cotton insects, as we all know, will also control other insects that can cause cross-pollination. In addition to the natural insect population, we have the problem of introduced bee population for the production of honey. Bees are excellent in assisting in the pollination of many seed crops, including cotton, but not when trying to produce seed with a double recessive characteristic. We must be honest in admitting that data is not available on what extent introduced bee population induces cross-pollination. However, experiences by some seedsmen indicate it might be serious.

Secondly, another problem is volunteer plants. Most cotton production today is from standard varieties. Consequently, it is very easy to have volunteer plants of standard varieties in areas where cotton is an important crop. A few volunteer plants in a production field of standard varieties is

insignificant, but the occurrence of the same number of glanded plants in a glandless production block with insect population and winds could result in cross-pollination and detectable off-type plants. This problem can be handled with cropping history requirements at a price. However, the practical question a seedsman must answer is, "Do the F1 plants contribute the same amount of gossypol as the volunteer plants; and if the level is lower in the F1s, what influence will it have on the next generation of seed to be produced by the former?"

Lastly, because the vast majority of commercial cottons produced are the standard varieties, avoiding mechanical mixtures is a great problem. This too can be handled managerially at a price. However, one must remember that farmers, seedsmen, ginners, truckers, and others involved in the chain of producing cotton must stay in business until we have passed through the transition period to all glandless cottons, or if glandless continues to command only a part of the total cotton acreage. If we transcend to all glandless varieties, varietal purity with this one characteristic will be solved for every speaker on the panel. However, in the transition period, or if glandless cottons continue to be a part of the total market, these new problems will be constant problems for all of us.

Traditionally, most cotton breeders have chosen to produce seed of their varieties under seed certification. With the passage of the Plant Variety Protection Act, certification continues to be an attractive method of producing seed. The long-established genetic standards are easily attainable when producing seed of standard varieties. However, with the introduction of the glandless characteristic, many commercial companies are having second thoughts.

Why these second thoughts about certification? There is one major reason -- once a variety has been placed under Title V of the Federal Seed Act, specifying that seed can only be sold as a class of certified seed, it cannot be removed. Under present certification standards, seed rejected for certification could be totally acceptable in producing commercial seed well within the tolerances established by the Food and Drug Administration. As you can see, this is a terrible risk -- one which most prudent businessmen should, and probably will, avoid.

Plant breeders, public and private, must examine closely the variety description in light of the probable occurrence of the characteristics in seed blocks. Let's examine the problems of producing glandless cotton planting seed, in light of the influence of the Plant Variety Protection Act and genetic certification standards, with what the food industry requires today. I assume that 450 PPM of gossypol is the upper limit of acceptable glandless seed products. In our standard procedure of going through life, we in certification have been going backwards. We have established standards on glandless cottons based on our past experiences in glanded cotton. We automatically classify glanded-type plants in glandless production as off-types. I do not argue with the correctness of the appearance of the plant, but I do question if we have fully examined the rate of occurrence of such an off-type plant which has varying levels of gossypol, to the market value of the product of the glandless seed. The present AOSCA standards for cottonseed for off-types are as follows: Foundation - 0; Registered - 1 in 35,000 plants; and Certified - 1 in 7,000 plants.

The cotton section of AOSCA a few months ago recommended a change to the following: Foundation - 1 plant in 10,000; Registered - 1 plant in 5,000; and Certified - 1 plant in 1,000.

The recommended changes are, in our opinion, an improvement, but in the

opinion of most seedsmen and many cotton breeders -- including public breeders -- the new standards, when finally accepted in about 18 more months, are still more stringent than practical to produce a very, very satisfactory commercial glandless cottonseed product. Certification can be a very important tool for breeders to use in producing seed with such chacteristics as glandless, but it must be practical.

This reminds me of the period of my life when I was a manager of a fair. Agronomic crops were of great economic importance to the area the fair served. We spent hours upon hours trying to develop contests on increasing production that would stimulate interest among farmers and city dwellers as well. Contests influenced by past experiences of determining winners by the largest ear of corn or the largest cotton plant with the most bolls, etc. never passed the test when compared to recommended practices for getting higher yields. The winning corn growers under the standards of appearance alone would probably have been last in net income, and the last place winner might have shown the greatest net return.

Apply this to producing glandless cottonseed for commercial use. I think we must start at the consumer level, namely those using glandless seed products in food items, and work our way back to planting seed production. We have heard some remarks by other than seedsmen about the levels of gossypol that determine an acceptable and unacceptable product. This and FDA standards should be our goals.

Referring to the recommended genetic certification standards, I raise the question of what is the relevance of 1 off-type plant of undetermined amount of gossypol to 1,000 glandless plants in the final product? I further question a true understanding of the problem if an off-type plant's seed contains only 50% of the amount of gossypol being counted as equal to a fully glanded plant.

Please do not misunderstand me. I am in no way criticizing my many friends in certification, but I do strongly question whether all who are connected with this problem, including all research personnel and potential users, have studied the problems of seed production in relation to its intended end use. One of our Texas breeders commented to me, "Genetically and theoretically, we can produce certified glandless cotton planting seed if we have absolute control in our breeding blocks, perfect isolation, perfect insect control, clean land, and no mechanical mixtures -- but is such a goal practical and needed?"

To those who are in the food industry, I want to assure you that we will produce planting seed of glandless varieties to meet your needs if there is an honest "buck" to be made by a seedsman. We recognize that you have little interest in our problems except as these problems affect you. We think seed certification and the Plant Variety Protection Act will be beneficial to all interest groups as we proceed toward the further development of the glandless cottonseed market. Hopefully, alternatives will be made available to seedsmen based on what is reasonable quality of non-glanded products to expand the total market for cotton.

PURITY MANAGEMENT ON THE FARM

By Tom Cherry

In covering the subject of maintaining absolute purity of a variety on the farm, as will be necessary if the farm, or the area, is planted to both glandless and glanded cotton varieties, I'm afraid I will probably raise more questions and problems than answers and solutions. Since we have had very limited experience in producing a glandless variety on a commercial basis, I am certainly no expert in this area. However, we do have an effective program of maintaining varietal purity between two or three cotton varieties that we are presently producing and several of our procedures would certainly apply to producing glandless in the presence of a glanded variety.

From a growing standpoint, the most critical time to assure the purity of a variety is in all stages of reproducing the variety for planting seed. If seed contamination or cross pollinazation occurs in any of the reproduction stages, the end result could be disastrous.

Purity management on the farm commences with field selection. Prior year cropping to cotton of a different variety, or particularly a glanded variety, would be critical in temperate areas where cotton plants tend to grow voluntarily from the prior year's seed or incomplete destruction of the prior year's plants. From a planting seed standpoint, proper isolation of the field from a glanded planting would be absolutely essential.

In our planting seed program we require a one-half mile isolation zone between the planting seed variety and any other planting of a non-Acala type or other species of cotton. In all early stages of our seed reproduction program, we require a one-quarter mile isolation zone with the succeeding year's generation of the same variety to be reproduced. In the final stage of reproduction, we require a 250 foot isolation zone from other varieties or strains of the Acala type.

Experiments conducted in the San Joaquin Valley to determine the amount of natural cross pollinization in a field of cotton have shown that this occurred at the rate of approximately two to three percent. This would be affected by plantings near flowering orchards or groves, or where an abundance of bees were imported to pollinate adjacent field crops.

Experiments have also shown that bees will forage for pollen up to a maximum of about four miles. However, they usually forage only as close as the nearest pollen source and each bee generally forages a specific area. In other words, a particular bee visiting field A would not likely visit field B before returning to its colony.

Because of pollinator populations, isolation requirements may have to vary from area to area, but I believe in the San Joaquin Valley we could satisfactorily maintain glandless purity with our present requirements as outlined.

Field selection from a planting seed standpoint should also include relatively weed-free fields.

Seeds from certain weeds can also be a source of contamination from a milling standpoint.

After the field is selected and about to be planted, planting equipment should be inspected to be assured that there is no seed residue from a prior planting.

Planting seed bags should be clearly marked as to the identity of variety and everyone connected with the planting should be familiar with these markings. This is particularly critical if any spot replanting is required. There has been more than one field contaminated by someone going to the barn for that few pounds of seed close at hand to fill blank spots in a field.

Once the stand is established, maintaining purity during the growing season should pose no particular problem.

The next step of harvest can be a process that can cause the greatest chance of contamination if more than one variety, or a glanded and a glandless variety, is grown on the same farm.

First, all harvest equipment, including pickers, trailers, rickers, module builders and transporters should be carefully inspected to be free of any remaining seed cotton. Picking crews and equipment should be assigned to a particular field and remain there until the harvest of that field is completed.

The increasing trend towards a method of ground-storing seed cotton furthers the chance of seed mixture when the seed cotton pile is picked up weeks or months later and recollections are vague about the identity of the pile. All ground-stored piles of seed cotton should be clearly marked at the time they are constructed. Aerosol spray markers or adhesive signs on the pile coverings are effective for this purpose. Trailers should also be labeled with an identification tag.

Perhaps the most important thing is that all personnel involved in transporting the seed cotton to the gin be aware of the identity of the seed cotton and make sure this information is properly recorded on all of the gin records.

Fortunately, in handling seed cotton of glandless and glanded varieties, if there is any doubt regarding identity, an examination of the seed for the presence or lack of pigment glands would be a means of positive identification providing the entire pile was from the same source.

Certainly, the best way to attain ideal purity management on the farm is for the farm to be devoted to only one variety of cotton.

As you know, the San Joaquin Valley of California is a one-variety cotton district by state law. If and when a glandless cotton variety is developed that will maintain or increase current yield levels and have at least equal or superior fiber properties compared to presently grown varieties, it is our opinion that the San Joaquin Valley will be in an ideal position to maximize the potential of producing a glandless variety of cotton with absolute assurance that there would be no contamination through any of the processes that cotton is exposed to. As glandless plantings increase in other areas of the cotton belt, it may become necessary, or certainly desirable, to establish voluntary one-variety districts or gin communities to avoid the possibilities of seed mixtures that could result in a serious consequence on large quantities of seed stored at a mill point.

In summary, purity management on the farm should include selection of fields with proper isolation and prior cropping history, assure cleanliness of all farm harvesting and handling machinery, inform all personnel of the object to be accomplished and, if possible, devote the farm to producing only one variety.

PURITY MANAGEMENT AT THE GIN

By Edwin J. Gerik

I would like to start by saying that my part on this program should be simple, and it could be summarized in one statement; that is, the best and the easiest way to maintain purity at the cotton gin is to gin only one variety of cotton. However, I realize this would not be possible in most cases, especially at the outset of glandless cotton production.

We have never ginned glandless cotton in quantity; and at this point, I am not familiar with purity requirements for glandless cottonseed as a food product. However, we are registered cottonseed producers and have considerable experience in maintaining purity in the different cotton lines we grow. We have also grown and ginned cotton for the Foundation Seed Section at Texas A&M University which requires a high degree of purity. With this background I will relate from our experience some of the problems involved in maintaining seed purity at the gin.

Essentially I see no real difference in ginning and maintaining purity in glandless cotton and in ginning and maintaining purity in any registered or certified lines of cotton. There are two problems a ginner has to consider; first is a complete thorough cleanup of all machinery through which seedcotton and cottonseed moves; and second is good customer relations-- the latter being because in almost all situations, when a farmer delivers a load of cotton to be ginned, it is customary that it be placed in line and ginned in line as it is brought in. This is important to the farmer especially during peak harvest periods when gins are normally crowded, and the producer is waiting to get his trailers empty so that he can continue his harvest.

It is almost impossible to cleanup a cotton gin in order to be 100 percent free of any hanging seed cotton in the overhead machinery or remaining seed in the conveyors. The amount of time required for a cleanup will depend on the type of gin system used and the extent of purity desired. If auger conveyors and bucket elevators are used throughout the gin, it will be more difficult and time-consuming to clean up. When pneumatic seed pumps are used less cleanup time is required since seed normally does not hang in the airlines. In our case, a shutdown time of about two hours with four men working in the all-conveyor system would be necessary as compared to one and one-half hours in the gin with the pneumatic seed pump. However, every gin plant is somewhat different, and in each case cleanup time would vary some. So, it would be safe to assume that the average cleanup time would be approximately one to two hours. In addition to the cleanup, it will be necessary to gin at least one or two bales of the variety desired and run the seed through the system and into the normal seed container, before any seed is caught for which purity is required.

In order to take the greatest advantage of a cleanup, it would be desirable to "group gin" cotton. By "group ginning" I mean to set aside a number of bales to be ginned at one time. This number would depend on the individual situation, the number of potential bales and the number of growers involved. However, the larger the group of bales the easier and less expensive this would

be for the ginner; this lessens the possibility of mixing seed.

It would be well to consider the use of module builders in the harvesting and storing of glandless seedcotton. This system of storing seedcotton has become popular during the past two seasons with both the ginner and grower. It enables the grower to harvest his cotton at his convenience and during favorable weather conditions while preserving both quality and quantity of his cotton. It also enables the ginner to spread his ginning season over a longer period. How ever the moisture content of the seedcotton at storage time is a very important factor to consider. According to Lambert H. Wilkes of Texas A&M University, who pioneered the module system and has done extensive study on seedcotton storage, both seed quality and lint quality tend to deteriorate when the moisture content of seedcotton is in excess of 12 percent. This would be so with seedcotton stored in either trailers or modules. However, no study, according to Wilkes, has been made with glandless seedcotton stored in modules and its effect on glandless seed quality. He assumes that moisture content of not more than 12 percent should have no adverse effect on the quality of glandless seed.

The point I am trying to make is that in using the module system larger numbers of bales can be ginned at one time thereby making purity management easier. At the same time this eases the problem a ginner might encounter with his other customers who are waiting to get their cotton ginned. This may not seem as much of a problem to some; but to the grower, it is very important to harvest his crop while weather conditions are favorable in order to get the best quality and price for his cotton.

Purity at the gin can be maintained only to the extent of purity prior to the time seedcotton is brought to the gin. Mixing can occur at planting time, in the field during the growing season, and at harvest time. There is no way to improve seed quality or purity during the ginning process.

I see no real problem at the gin level in glandless cotton production. However, I would suggest to anyone interested in a growout of glandless cotton in a specific area to contact the gin manager. If he is not favorable to the minor inconveniences which will be encountered, it would be advisable to find one who is willing to cooperate.

I feel that if glandless cottonseed, with its high quality protein, can be promoted as a widely used food product in addition as a source of fiber, it would certainly strengthen cotton's position as an industry. Ginners look favorably toward anything that can put the cotton industry on a more sound, stable, permanent basis. I feel glandless cotton production can do this.

PURITY MANAGEMENT AT THE OIL MILL

By Charles Hay

All of the more difficult problems have been taken care of by the gentlemen preceding me, so that makes purity management at the oil mill easy, by comparison. Certainly the integrity of glandless cottonseed must be maintained throughout seed receiving, storage, processing and product handling, or all the previous effort will be for naught.

Purity management at the oil mill must begin even before the gins start operation. The mill manager must determine first whether or not the glandless acreage and projected tonnage is sufficient to justify tying up a part of the unloading and storage facilities, and separate processing for the glandless.

I realize that I am encroaching on territory already covered by others at this conference, but these are things that must be considered by the manager in determining the volume of significance for his particular mill. There is no way that I can come up with a formula for this determination, since each mill has different capabilities; but the manager must decide if the volume will justify the cleanup of the mill necessary to eliminate any possibility of contamination through processing, and if it will justify separate meal storage and the handling of two meal products, and if it will justify separate oil storage.

The cleanup would involve thorough removal of all old seed from the truck dump pit, conveying and elevating equipment, and seed house or houses. This would include any seed hanging on the rafter trusses, purlins, drag belt trough and all pits. Then when the mill is ready to process the glandless seed, the entire mill should be cleaned in the same fashion, with all the machinery opened up for cleaning. There is an alternative for cleanup of the processing equipment, and that is to purge the plant with glandless and sacrifice the first production to the regular glanded seed products. Ideally both methods should be employed.

In addition to the cleanup costs, there may be some indirect costs to consider. The volume of glandless may only partially fill one or more seed houses, forcing regular seed into outside storage with the possibility of resultant lowered quality. There may be a marketing loss involved in emptying oil storage facilities for the changeover in seed type. There may be extra labor or extra supervision involved in handling two meal products, et cetera.

In order to compensate for these extra costs, there must be extra income to justify segregation of the seed; and this extra income can only come from two sources: (1) reduced refining loss, and (2) expanded meal market for poultry and swine. The gain from reduced refining loss is real, but the gain from an expanded meal market is imaginary until such time as the volume is sufficient for a year-around supply for the feeder. It would be difficult to persuade any feeder to change his formulation for only a short period, and it is doubtful that this meal would bring any premium over regular cottonseed

meal. After a continuing supply has been established, glandless meal may then be priced close to soybean meal.

Theoretically, the refining loss of glandless oil should be reduced approximately 0.8 percent, but in practice it would be somewhat less. If we assume an oil yield of 335 lbs. per ton and 20-cent oil price, we will gain about 40 cents per ton of seed from this reduction in refining loss.

Clearly then, it would take a sizeable tonnage to recover the costs associated with segregating the two crushes. For the average mill I would estimate that the glandless crush should be between 25 percent and 50 percent of the total crush to reach the breakeven point.

There is another viewpoint, however, which says that even if the mill can only get just a few day's crush of glandless seed, the expense is justified as an investment in the future. The meal could go to selected feeders for their evaluation and to create a demand for the glandless meal. And the oil would not necessarily have to be separated for the mill to benefit from the reduced refining loss.

So, let's assume the manager has decided to proceed with separate unloading and storage for glandless. He should then advise all mill personnel of the purpose, intent and importance of keeping the glandless seed separate from the regular receipts, and which facilities have been assigned for that purpose. The gin shipping the glandless seed should send a ticket with the truck driver, certifying to the mill that the load is glandless; then, when the truck weighs in at the mill scales, either the truck or scale ticket should be flagged in some manner so that it will only be allowed to unload at the designated facilities. The dump operator or unloader should be cautioned to unload only glandless cottonseed at that point, and if there is any question about a particular load, it should be sent to another unloading point.

It might be wise to have either the scale clerk or the dump operator cut a number of seed (maybe 15 or 20) to make certain they are predominately glandless, because by the time the laboratory gets the sample, it is too late. Simply asking the truck driver if his load is glandless is not the best way to get reliable information either.

If we accomplish effective separation at this point, the most difficult part of our job is over. Cleanup of the processing equipment, storage bins, etc. is merely routine. We could run into trouble in the meal room trying to handle two products through the same equipment, but with a little extra supervision, it can be done. There are a number of mills that now handle soybean meal and cottonseed meal through the same equipment by simply purging the cottonseed meal from the system with soybean meal and using the blended meal in a mixed feed.

Up to this point I have neglected to mention the possibility of an oil mill's producing an edible quality meal or flour. The type of cleanup described previously would not be adequate for edible production; but here again, until we can produce a continuing supply there will be a very limited demand. When the time comes that we can supply a year-around market, I believe an oil mill can make the necessary changes and cleanup for edible production. This has already been demonstrated at two different plants.

DISCUSSION OF PAPERS ON VARIETAL PURITY

P. J. WAN I would like to make a comment on the 300 ppm gossypol tolerance level Dr. Phelps mentioned. This number was established on the basis of the color appearance of wet cottonseed flour. The tolerance level will obviously depend on the kind of food system in which the cottonseed flour is used.

J. FOSTER I would like to address Mr. Gerik. If the farmers modulize their seed cotton, have enough trailers or whatever it takes to get this in a block situation, do you foresee any problems if you postpone the ginning to run all the glandless as a block? Is this going to be a problem for the farmer in his marketing plans? What if he wants some of this fiber early in the season so he could go along with his marketing plans and projections? Is he going to complain or want the price difference if you wait until later in the season when you have all the block together and the price may have dropped? Do you see any problem with this?

E. J. GERIK No, I do not think so. I think it would have to be worked out on an individual basis. I would hope that he would wait until the end of the season or at the time when this group could be ginned to market his cotton. Of course, sometimes, they may need the money and want it ginned immediately. I think that would be an individual situation and depend on what size block would be involved.

S. P. CLARK I would like to make some comments on what I have been thinking about here. It seems to me that the next step we should concentrate on in this whole area we have been discussing for the last two days should be along the lines of getting oil mills, gins and seed producers to work together, and produce glandless meal for animal feed. The reason I say this is that, first of all, it seems to me that we need a big acreage in order to get the experience that we need to solve some of the problems that have been discussed this morning. I realize that there are a lot of questions about whether we are ready to go this way right now; however, maybe we are ready in Texas, from the things that have been said. If we had a bigger production of seed, for instance, then we would have more selection of seed for food uses. If there were bad seed produced, field damaged seed, then this could be converted into ordinary products and not have to go into the higher quality outlets. Another reason why it seems to me this is the correct approach, is that as far as markets are concerned, glandless meal has a market that is probably easier to develop and closer at hand than the market for human food. Another reason is that the purity of the seed probably would not need to be as great for meal as it would for human food. Seed purity would be easier to manage in the areas we have been talking about this morning. Another reason is that processing can be done in present oil mills; there is some question as to whether processing for human food can be done in present oil mills. This has been debated among people in research and I am one of those who sort of tends to believe that to produce human food we are going to need to have either a new mill or one that is very much upgraded and carefully engineered in order to preserve the quality of the product after it is produced. Now, one other comment I would like to make. It seems to me

that in the old days before soybeans were introduced into this country in a big way, if someone had looked at the oriental experience and said what a tremendous opportunity there is to put soybean products into human food and they had started out in this direction to try to produce soy products for human food, I do not know whether it would have ever been successful. But the way it went was in the other direction. The animal food came first which is what I have been suggesting. Of course, processing the oil really was the reason why they started producing or processing soybeans. Animal food was produced first and then human food came along as an outgrowth of that, and it really seems to me that this is the way the glandless ought to go.

M. J. LUKEFAHR I would like to ask about the precision of the analytical techniques for gossypol.

P. J. WAN Based on our experience, at 300 ppm total gossypol level, the error range would be around 50 ppm if the AOCS procedure were followed.

R. J. MIRAVALLE You know, a number of years ago, when the liquid cyclone process was developed I was working at that time for the National Cottonseed Products Association as a plant breeder specialist. The breeders I contacted were always asking what about this and asking now that we have a mechanical means of processing glanded seed, do we need glandless? And I said "yes" we do and that this particular process (LCP) is an ideal process for cleaning up the seed during the early stages of the development of production of glandless seed so that we do not have to worry too much about contamination. I thought that it would be well worthwhile to bring this point up again during this session because I still think that we could eliminate a lot of the worries and problems with contamination through the use of the liquid cyclone process. It would automatically, it seems to my naive way of looking at it, eliminate all sources of contamination at the processing point. Would the panelists care to comment on that?

C. COX I think, Dr. Miravalle, that the panel will take your comment as a statement of fact. We of the Natural Fibers and Food Protein Commission of Texas have been very interested in this business of glandless cottonseed ever since California sent us 5,800 pounds of glandless seed and we were privileged to do the first pilot plant processing at Texas A&M University. We have had a lot to say during this meeting about glandless cottonseed; however, for some reason the perspective has not really zoomed in from my angle. My angle is that when you can say food and fiber you are saying something that certainly all of us in this room will listen to but the amazing thing is that when you say food and fiber talking about a plant that produces both for human usage then you are getting attention of the man on the street, you are getting attention of the urban politician whether it be in Austin, Mississippi, California or Washington, D.C. Also, to be a little more specific about the importance of being able to say "food and fiber", I believe we can say on our research budget of Natural Fibers and Food Protein Commission's $2,320,000 fiscal year 1978, it would be under $1,000,000 if it was not for our work with glandless cottonseed. Each of us know how we need research dollars and I think our total budget increase has been because of this sort of progressive thinking both from the Plant Pathology Research and that of the Oilseeds Research Center. We have spent an average of $100,000 a year during the last eight years in the State of Texas budgeted on glandless and this includes the plant breeding area,

the area of nutrition, the area of spinning glandless fiber. We have the data from the processing side of both fiber and the glandless cottonseed kernels. If you ask the question, "Can we get the farmer to grow it?" The answer is "yes." But first he wants to know specifically the yield and how does it spin? I have an IBM printout about a variety that was just mailed from Mr. Gregg of Plainview, Texas, and I do not think it specifically was identified as Gregg 35W but I have in my hand an IBM printout with total information fiber data that is as good as any cotton fiber data we have seen in any of our variety tests. If any of you are in spinning you can appreciate yarn with 3,000 level break index on 22's - this rates with our best irrigated areas of spinning values.

I would also like to have in this proceedings something from the nutrition side. Time and length of the program would not permit including human nutrition; however, without proof of the nutritional value of this new protein we would not be where we are this day. Giving proper recognition we would have to start with Dr. Pauline Berry Mack, the late Pauline Berry Mack, Dr. Karl Mattil, Dr. Carl Cater, then people like Dr. Betty Alford, Dr. Rita Thomas, Dr. Matthews who did the basic work on the bread, Dr. Meinke on the extrusion phase of our research, Dr. Harden's high protein cookie research at Texas Tech. Dr. Yang, Dr. Jim Lawhon, Dr. Stan Matlock, Cecil Wamble, Dr. Khee Rhee and then Mrs. Judy Green who fed 133 people not too long ago at Texas A&M and every item in the menu had glandless cottonseed; that is all the way from the main entrees to the desserts and parfaits. Now, going one more step bringing other women into this story along with Wilda Martinez. Wilda, you have a lot of company in this area, a Dr. Gladys Sutherland, who probably none of you have heard about at this point, will report in a medical journal setting forth probably one of the truly most interesting areas that we have ever had anything to do with in the feeding area of infants--that is, a mongoloid child that we started feeding the high protein glandless cottonseed at the tender age of about three months. These are the things I wanted to have heard so if any of you want to go into detail from any of these people I have just named they have a wealth of research data to prove that we are not barking up the wrong tree when we are saying that glandless will become a food product in some form in the very near future.

SUMMARY REACTION TO PAPERS ON VARIETAL PURITY

By A. L. Vandergriff

The group making up this panel has done such an excellent job in presenting their story, they don't leave much room for reaction as far as their particular papers are concerned. I do want first to make some general comments about the meeting from which, I hope, we can end up on an encouraging word in spite of all the negative factors that seem to keep creeping into our program.

The whole thrust of this meeting, I believe, will finally resolve itself in the identification of which direction we should take. That, to me, is the most important factor in the whole program. Of course, in the final analysis, we will determine the direction, and I think, it is up to us to push and maybe hasten the progress based on the economic opportunities that are going to be available to us. The many segments involved and the interaction of the various factors of each segment make it a rather complicated situation. One feels we can go in this direction, and another feels we can go in that direction, this one finds reasons why we can't go, and others find reasons why we can. It gets to be very complicated. I hope that we are not saying today that there is not going to be much progress in our glandless program. I do not think that is what this conference is telling us. But it is a complex situation.

In the direction of simplification, I have wanted all through the meeting to come up with some better word than "glandless" for this seed, and I hope you'll give some thought to that. I think that glanded and glandless gets confusing, and let's find a better word for this seed, something that would compliment it more.

As to economics of glanded vs. glandless, we might look at it in about three phases. Certainly one phase that we have to continue to look at is the regulatory problems we may be facing. For obvious reasons we don't want to say too much about this with our present gossypol levels being what they are. This is somewhat of an intangible, but it should be a plus factor in encouraging us to reduce the gossypol level. This is especially significant when we consider that the mood of our country doesn't lend itself to our continuing to sell a product which may be toxic to animals under certain conditions.

The second economic factor, of course, is that of the potentially improved market for lower gossypol or gossypol-free protein in animal feed, and for human consumption. The potential in animal feed seems to be real and rather readily available. That for human consumption is probably just as real but more difficult to attain due to the need for extensive changes in the processing facilities.

The third factor in the economic potential is that of improved oil quality and lower processing costs, including energy savings.

Looking a little more in detail at the individual segments of our industry, first from the farmer's standpoint, yields do not seem to be a major concern. The breeders seem to be able to produce comparable yields. The pest management problem appears to be a factor, except for west Texas. More testing is needed to convince the farmer in most areas that he can grow glandless.

The problem of clean-up at the gins has been discussed and it is a real factor where both glanded and glandless might be processed. The costs here along might more than offset the advantage of glandless.

The oil mill, as it is presently constituted, is probably O.K. for processing glandless going into animal feed, at least under present regulations. The mill would have obvious serious problems as Charles has pointed out in trying to process both glanded and glandless. And, of course, these costs have to be weighed against some rather insignificant improvements in oil and meal prices. I believe Charles mentioned a figure of $10 per ton more for meal from glandless vs. glanded in animal feed. There would be some variations in this especially in the pet food potential, but $10 per ton of meal is less than $2.00 per bale, so we can't do much cleaning up at the gin and at the mill with this kind of potential. The regulatory problem, however, may be a significant factor in the future even in pet foods. So, this factor should be plugged at some figure.

The human food potential is long-range and, except for some specialty items, is pretty much an unknown at this point. We do know it would require developing markets and building new processing facilities, as well as the potential for another round of regulatory problems.

Now, more specifically to the panel that's up here now, they have done an excellent job in presenting their case.

In closing, I would like to again emphasize, and I hope all share this feeling, that this meeting will result in a positive direction for us to follow. Glandless has many potential advantages, some long-range, some short-range, and the disadvantages are generally temporary and can be overcome as we face them. So, without getting into the territory of those who are to follow me with the conference summaries, I will say again that I would like to see the conference end on a positive note, and that we will move ahead in facing our glandless problems. I think it is going to require a lot of help and maybe even the industry should hire a full-time coordinator to keep the information flowing to those who need it. I think with this kind of effort we will move ahead with glandless seed. The rate will be somewhat determined by how we feel about it when we got through here.

ASSESSMENT OF ECONOMIC INDICATIONS

By Arlie L. Bowling

I very humbly and with considerable reservation approach the task of assessing the economic factors presented at this conference. Lifetimes of research and volumes of information cannot be adequately summarized in a few minutes. A long assessment would not provide impact. A short one is subject to oversimplification.

This assessment will be relatively short and relate to the information presented at this conference and even then one must be selective.

The direction our industry should move with glandless seed cotton can probably be measured best by examining the economic impact of changes that may occur if we grow and process glandless cottonseed rather than glanded seed. These changes should relate to total revenue, cost of production and to the health and viability of our industry. How would these changes affect each industry segment, and, further, does sufficient economic incentive exist to bring about these proposed changes?

To consider these questions requires information. The information you have presented at this conference is very comprehensive but also very complex. These excellent research papers have dealt with the actual production of glandless seed and with the market characteristics of cottonseed protein. But, information on what the market will actually pay for glandless cottonseed protein is not yet available. Why is is not yet available? Because we have not yet produced enough glandless cottonseed materials to provide the resources to test it in the marketplace for various product uses whether for animal or human consumption.

What are the implications of this lack of market information?

Good marketing requires a customer orientation. Products should be developed or produced to serve the customers' needs. Experience has shown that those firms which develop products oriented toward serving first the producers' needs seldom are successful. We must be customer oriented.

Market information which will adequately define how customers can use our product and how much they will pay for it cannot be forthcoming until we produce some glandless meal, flour, concentrates and icelets in sufficient volume that commercial firms can develop and test the market.

Commercial use of such pilot production can develop information from which consumer demand can be measured. This is an essential step.

The development and marketing of any new product, glandless cottonseed included, incurs high risks. When the risk is high, there must be a compensating payoff for that high risk.

Let's examine the information to see if there seems to be adequate rewards that would merit moving onward with glandless cottonseed.

Cottonseed's major markets have been oil and meal. Let's examine the impact of glandless cotton on these conventional markets.

1. According to N. J. Smallwood, clear oil is preferred for markets like salad oil and shortening. Soybean oil has the advantage of

being light in color. By contrast, cottonseed oil requires overcooking to meet color standards. Glandless oil could meet color standards without additional processing, thereby enhancing cottonseed oil's 1½¢ crude price advantage as well as reducing processing cost by .7¢/lb. Glandless oil would avoid color reversion problems and thereby enhance the value.

2. Energy savings in a model 300-ton plant would be reduced about 50% when processing glandless seed compared to glanded seed. Energy costs vary greatly among plants, but Leslie Watkins indicates the operating costs of the processing plant would be reduced by at least 4%. This energy saving should enhance profits and improve competition through lower costs. In view of the increasing costs of energy, this would be a significant saving.

3. Meal produced from glandless seed would have broader market opportunities for increasing revenue. Dr. Wilcke indicates that pet foods would be a plus market factor. This is a 4½ to 5 million ton market.

   Milk replacers would also be a good market if a flour could be produced.

   Increased quantities of glandless meal could be properly used in poultry and swine rations.

   Feed formulators would increase their use of cottonseed meal as their concern for gossypol decreases.

   These factors should result in stronger prices for cottonseed meal.

To summarize impact on conventional products, glandless seed would result in more efficient production. It would greatly reduce the amount of energy required for processing seed and thereby reduce the cost of production. These conventional markets would be expanded which should provide greater revenue and profit opportunities. Oil and meal markets will likely remain the backbone of the industry for many years and their market improvement would be most significant.

High protein cottonseed products from glandless seed offer additional market opportunities. We do not have actual price information on such products, but we do have some indicators about price. And in these markets, a product must be price competitive if it's to be successful.

Dr. Lugay indicates that cottonseed's very high protein content meets the nutritional requirements to compete well. However, the functional attributes of cottonseed protein must be adapted to products through product research, development and product testing. This will be done by the commercial firms that will market the final products. Market success or failure will be based on their judgments.

However, Dr. Lusas of Texas A&M illustrated some of these high protein products on the screen yesterday and stated, "Enough research has been completed

to show that they offer considerable potential to food processors. Let's get on with their production and commercial use!" Also, his estimated prices for cottonseed flour suggest a favorable market opportunity.

Dr. Wilding advises that glandless cottonseed protein has a strong market potential in dairy products. Dairy products constitute 22% of our per capita consumption. Since 1965, milk production has decreased by 3% while population has increased 11.5%. Further, milk production is expected to continue to continue to decrease, and world population is projected to double in 40 years. This indicates a major short fall in dairy protein production. Cottonseed protein can help fill this nutritional gap.

The conference evidence examined to this point is that the potential demand for glandless cottonseed products is much greater than for glanded products.

So let's now examine some of the constraints on moving to glandless cottonseed.

1. As mentioned earlier, we must produce sufficient glandless products to develop and measure the market potential. To date, this has been a major constraint.

2. An adequate supply is essential if we are to optimally develop new significant markets. Cotton seed production is inelastic to seed demand. As indicated by Kromer and Martinez, cottonseed supply is determined by the demand for cotton lint.

   Research may be needed to develop larger and better seed as suggested by Wilda Martinez to influence supply availability.

3. Individual cotton industry segments lack incentive to move to glandless seed production on their own. A vertically integrated or coordinated program is needed to provide the management to attain the rewards comparable to or greater than glanded cotton. These revenue rewards are a must to provide the incentive for growers, seed firms, gins, mills and others to move to glandless cotton.

Each industry segment has significant problems to overcome. Producers have unknown risks regarding yield, pests and purity. The many excellent papers presented at this conference indicate that progress has been made on these problems. Many problems still exist. But most researchers indicate that if the economic incentive to produce glandless cottonseed is sufficiently strong, the production problems in most instances can be adequately dealt with.

Dan Pustejousky showed that growers need all possible revenue from their land and that they will grow glandless cotton if they have even a small economic incentive.

Purity is also a problem with seed companies, gins, co-ops and mills. The technology to their purity problems exists, but costs will be incurred.

Capital investments must be made by some segments, particularly the oil mills. The success of the capital investments depends upon adequate

performance by all other industry segments in the glandless seed production and processing chain. Therefore, close cooperation, coordination, and control is needed between growers, ginners and mills to reduce risk so that required capital investments will be made.

In conclusion, the potential for both increasing revenue and decreasing processing costs provides the opportunity for all segments of this industry to enjoy a more healthy industry.

As total revenue for end products increases, the revenue available to the seed company, the cotton grower, the gin and the mill increases. This economic benefit should provide the necessary industry motivation.

I feel that the evidence presented at this conference recommends the growth and processing of glandless cottonseed.

Additionally, both Garlon Harper and Leroy Schilt show that it may also be well to move on to glandless cottonseed because of the high risk involved in the marketing of a gossypol toxic product in our society with government so strongly oriented toward regulation.

The future economic health of the cottonseed industry should be greatly enhanced by moving to glandless cottonseed.

CONFERENCE SUMMARY

By Harold L. Wilcke

The purpose of this conference was to bring together groups of individuals representing, as nearly as possible, all segments of the cottonseed and related industries interested in the development, production, processing, marketing and utilization of glandless cottonseed. The objectives, as stated, are (1) to attempt a realistic assessment of the significance, status, and prospects for extensive commercial production of these glandless cottons, (2) to evaluate the relative economics of glandless vs. glanded cottonseed, (3) to analyze the possible advantages of glandless cottonseed in the utilization and marketing of the products, (4) to assess the current status of the glandless breeding, pest, and production management programs, (5) to consider methods of maintaining glandless purity, and (6) to establish better communication among the many groups interested and involved with glandless cotton.

As this program draws to a close, we should evaluate the degree of our success in meeting these objectives in each of the areas of discussion.

In order to put this industry in proper perspective, it was pointed out that the supply of cottonseed is relatively inelastic, because the seed is a by-product of the production of cotton fiber, and, therefore, the demand for fiber will determine the amount of seed that is produced. In this conference, however, the primary thrust throughout is to evaluate glandless vs. glanded seed, and not to attempt to assess the overall position of cottonseed products in the economy.

In considering processing costs, step by step, it is quite apparent that there are obvious and substantial economies because of the freedom from gossypol. Much less energy is required to process glandless seed because the solvent process would be the preferred method, with less solvent required per unit of production, less heating would be required, less energy in preparation, and some efficiencies in utilization of vapors, resulting in a total saving of approximately 50% in energy required, which is extremely important from the standpoint of conservation as well as cost.

In processing the oil from glandless seed, several advantages are apparent. First, the refined oil yield has been estimated to be about 3% higher for the glandless, the color would be improved sufficiently to avoid additional processing, there would be less bleaching expense, and the oil could be stored for longer periods of time. In comparison with soybean oil, the expense of hydrogenation would be avoided. There is a question here of how much of the market may be escaping the cottonseed industry because of lack of ability to produce the oil with color demanded by the customer - a demand that might be met with glandless oil. The differential cost of processing the glandless oil has been estimated to be about .011$/lb. more than soybean oil, and .007$/lb. less than oil from glanded seed. Therefore, the economics for both meal and oil production would be significantly better for glandless seed.

When cottonseed meals are used in animal feeds, all factors considered favor the use of meals from the glandless seed. Freedom from gossypol would permit the use of cottonseed meal in a much broader range of rations for monogastric animals, would place a higher value on the meals ($9/ton in the specific ration evaluated for laying heans, and $22/ton in the swine growing ration). Glandless cottonseed meal would be considered favorably for use in pet foods and calf milk replacers, both of which offer substantial market opportunities, and the glandless meals would be more competitive with soybean meal in many types of rations.

Glandless cottonseed, or "low gland content" seed, has been demonstrated to have a very good potential for use as a food for humans. However, any protein source to be used in food systems must be available in both sufficient quantity and reliable supply, it must provide good nutrition or desired functional properties, or both, the price must be competitive, it must have a desirable flavor and aroma, or free from undesirable characteristics, it must be compatible with other food ingredients, and it must be free of toxic constituents. In dairy food systems, color becomes quite important. The glanded cottonseed flours are almost certain to produce undesirable colors in the dairy type products. This problem is less severe with glandless flours, but there may be some problems, perhaps due to chlorogenic acid, with less problem from the yellow tints produced by the flavonoids. These pigments should be removed or minimized. As dairy production decreases, at least in per capita production of dairy products, there will be greater need for plant proteins to fill the gap.

Glandless, or low gland, flours have been found satisfactory in a variety of foods in laboratory scale applications, such as in cookies, bread, candies, and the flour has the advantage of a bland flavor. One of the most satisfactory uses of glandless seed for human use has been the production of Tamunuts, which may be used as a snack item, in candies, bakery goods and ice cream products.

When any class of products is offered as a human food, it must have clearance through Food and Drug, which may be accomplished by classification as Generally Recognized as Safe (GRAS) or through the Food Additive Procedure. The choice of routes to be chosen for the application for clearance will be dependent upon the individual circumstance. Extensive data must be supplied in either case and the procedure is usually rather lengthy, time consuming, and painstaking. Both animal feeds and human foods are regulated under the same basic law and essentially under the same regulations. However, since cottonseed meal has been used in animal feeds historically, clearance procedures with FDA would probably not be required for animal rations.

Other considerations in the development of glandless seed production were: (1) increasing the size and quantity of seed without affecting fiber yield per acre, (2) the use of gossypol as a factor in trading rules, (3) seed quality must be protected, particularly from contamination by glanded seed, or deterioration in rick and module storage. The production of glandless seed would protect against economic loss due to oil color reversion. The most satisfactory, efficient and economical methods of processing glandless cottonseed have not been worked out in all details. This is a new type of product which may require a certain degree of modification to fully optimize the process.

Cottonseed breeders have been quite successful in developing strains of glandless cotton that are quite comparable to the best glanded varieties

in production at the present time in terms of yield, quality of fiber, length of fiber, and other desired characteristics. However, in some areas, particularly in California, there appears to be an increased susceptibility of the glandless varieties to insect and rodent damage. This does not appear to be a problem in large scale production in some other areas. However, the possibility of loss of production through increased insect damage does act as a deterrent in the interest of the grower in switching to glandless varieties which will produce as well as, but probably no better than the glanded varieties. It is possible that some incentive will be needed to realize commercial scale production.

Any decrease in gossypol content is desirable, but breeding programs to simply produce cottonseed with lower gossypol content would not be a satisfactory solution. This would not be a simple program, and it would add tremendously to the breeder's problems. Neither would this provide improved income for the grower. The profitability to the grower, as well as to the other segments of the industry, must be considered in any new developments.

The work on pest control management leaves many unanswered questions. One of the primary conclusions that seems to be emerging is the fact that new varieties must be evaluated with respect to their total interaction with their environment, and that laboratory feeding of the various insect pests cannot be considered a valid measure of field effects of those pests. There seem to be relatively few pests which should be considered as serious hazards in the production of glandless cotton, and there seem to be several approaches from a morphological standpoint which will decrease losses due to insect damage. Among these are the nectariless and smooth characteristics. Substantial increases in use of pesticides are not a satisfactory solution because of regulatory controls and because of cost. In order to arrive at final evaluations of the problems of insect damage, or degree of susceptibility to disease, the glandless varieties should be compared under the best systems of pest control management available for the area in which they are to be grown. There are tremendous differences in the resistance or susceptibility to either insect damage or to diseases, among the various cultures of glandless, and these should definitely be explored. The system of approach, which utilizes multiple basic factors, rather than one which is directed toward any one specific problem seems to be yielding some of the most promising results in identifying new strains of glandless with effective resistance to insect and disease losses.

The question of susceptibility to rodent damage appears to be a local problem.

The maintenance of purity in glandless seed brings out very forcibly one of the unanswered questions of the conference. What is acceptable as glandless seed? We have not defined what we have been talking about throughout the conference. Several attempts have been made to suggest tolerance - no two of them precisely the same. If we accept the level of 450 ppm free gossypol currently used for glandless kernels, the economic advantages which could result for the feed industry are completely negated. Those figures were based upon a 100 ppm maximum free gossypol. Products from the glanded seed are already available which are lower than the 450 ppm level of free gossypol, so there would be no change in the use in animal feeds. We must, therefore, talk not only about free gossypol, but about total. Two other considerations should be brought into focus. One is the possibility of

regulatory control on gossypol residues in animal tissues, and the other is the question of the name. Is glandless an appropriate name for products with varying levels of gossypol? Seed certification proposals base the standards on number of glanded plants in certain populations of glandless. How is this translated to gossypol content? Certainly it will vary depending upon gossypol level in the contaminating plant. There are certainly problems here, because, until the crop is wholly glandless, it will be impractical to attempt a zero level of gossypol. The costs would greatly exceed the benefits. So, where is the practical level?

It should be pointed out, that in the meantime, research people working with so-called glandless cottonseed products should define these products very precisely, particularly in regard to levels of gossypol present, for many of the color and related problems may be erroneously attributed to gossypol-free materials where, as a matter of fact, the results may be due to residual gossypol.

Maintenance of purity, at whatever level finally established, will be an on-going problem for everyone concerned with glandless production, and in some cases the cost of purity maintenance will be the determining factor in the decision of whether to grow or process glandless. As pointed out, it can be handled, with a certain degree of education, effort, and cost. It was also pointed out that, while financial incentives may be necessary to get production of glandless, these incentives can only be justified when the volume is sufficient to make this a cost effective proposition. Of prime importance also is the need to create confidence on the part of the producer.

Judging this conference in terms of fulfilling the stated objective, we must conclude that it has been quite successful. One of the objectives was to establish better communication among the various groups. The California experience is one example where through a break-down in communication the gossypol content of the commercial varieties was permitted to increase to such an extent that a very significant part of the market for cottonseed meals in poultry feeds was lost. This also emphasizes the need for glandless cotton. Further, one of the characteristics of oil desired by the customer is a light color, which can be met with oil from glandless seed without the additional bleaching cost necessary for oil from glanded seed.

The response to all of the objectives of this conference has been positive. The economics of glandless compared with glanded are favorable in processing for both oil and meal, as they are in animal feeding, and distinct advantages are offered in human food products. The breeders have glandless strains which are performing fully as well as the glanded varieties, with the exception of some unanswered questions of insect and disease damage in some areas. Purity can be maintained. The unanswered question is: "How will the breakthrough to get volume production be accomplished quickly?"

Finally a proposal has been made that research funds might be used to set up a cooperative project between growers, ginners, and oil mill operators to produce and process glandless meal in sufficient volume to gain experience with use in the animal feed industry, while developing concepts and products for use in human foods. This suggestion should merit serious consideration.

T. B. MASON I'm a farmer from Tahoka, Texas. Five years, on my farm, I have grown glandless cotton in a varying number of acres. So I have some experience in producing it and in trying to maintain a lower gossypol content in the seed. But it seems to me as the gentleman just said we are not completely accurate when we call glandless cotton glandless. It would seem to me to be more appropriate for us to adopt, in as many cases as we can, the term of low gossypol material or low gossypol plants, because we are quite a ways from completely gossypol-free commercial production. I would like to make that suggestion for you folks to think about it.

J. WHETSTONE Before I forget it, I want to mention, this gentleman just up here is a very small farmer. He just grows 1200 acres of glandless. I was not going to say anything, but it is hard to keep quiet. Garlon and I were in on that original meeting with seed breeders back in Dallas. When was it, Garlon, 1959 or 1961? Well, it doesn't make any difference. At that time and representing the cotton oil industry, Garlon and I had looked at the markets for cottonseed meal. We had seen what had happened over several years and observed just what our market was for cottonseed meal. Then this opportunity came along for glandless development. At this first meeting, we looked at it purely from what we could do with our cottonseed meal for feed, and we felt at that time, it was worthwhile. We did know we had a potential for these other things that could come along in oil and probably in food. I think our research program here in Texas shows that we have worked toward these things for 16 or 17 years. Now, I just want to leave one thing here from that original thought that we had. I think glandless development is still justifiable for this reason alone and I wish we had some of our farmers here. I think they have gone. At least, we had one who was just up here. I think we all know that our markets do form the basis of what is paid for raw cottonseed by the oil mills. Let me give you one example, I think you all can understand this. Cottonseed meal today--of course, depending on location--is bringing about $145 to $150 per ton. Cottonseed meal next April when the cowboys figure they are going to have grass is bringing something under $120. What I am saying here is this has been reflected in the price of cottonseed. At the same time from April forward, if you look at markets, soybean meal is really stronger around $160 to $170 per ton or $50 per ton higher than cottonseed meal. We definitely have an increased value and market for glandless cottonseed meal if it was available in volume.

H. L. WILCKE In regard to the first gentleman's comment, yes, I would much prefer that type of terminology, "low gossypol," rather than glandless or gossypol-free, certainly. I think we are in the same position the high-lysine corn people have been in. Some of those folks want to call anything with the opaque 2 gene high-lysine when, as analyses show, the lysine content varies all over the map. I think that we are at the point where we should be deciding what we are talking about, and I certainly would like to hear a little discussion from this group.

A. B. WATTS I am an animal nutritionist and there were conferences prior to 1959 on this subject.

I think back in 1951, Mr. Ward called the first one. You might be a

little surprised to know that the objective that we developed for our work at that time was to eliminate gossypol from cottonseed meal. Two years later, we faced the reality and reduced our challenge to getting it low enough to live with. I sat here with great interest during this conference because you have far more powerful tools today to accomplish that original objective and you now have our second objective at your fingertip. I am elated. We were the first, I believe, to be able to feed glandless cottonseed to chickens. We were in a completely different ball park than what we had been before, but this was done in batteries in small numbers because we never had the commercially produced quantities.

Now just to comment on the name. I think the soybean industry faced a somewhat similar situation years ago when they decided to go from a 41 and 44 percent to a 50 percent protein at that time. They wanted something to separate it from the old product and, Harold, if I remember correctly, Staley came out with the term "Hi Pro Con" and others, Arthur Daniels Midland and Central Soya got into the picture. Today, we talk of soybean as 44 and 49. What we need is some little gimmick that would separate it from the thinking of the old line and, once it was established, it would probably find its place as cottonseed meal but with the inference of no gossypol.

Now may I lay down for you a small challenge. I am very intrigued with what Harold said about the possibility of using some funds to produce quantities of this material. We have the facilities to be able to conduct a rather large test in a house that will have 60 pens of 100 chicks each in it, and I would be happy to run an experiment and generate some of this information you need to get your foot in the door of the poultry business. If you will get me three tons of a meal, 44 percent protein, minimum (preferably 49), with 100 ppm or less free gossypol and a mild cook, (minimum damage to the protein) and three tons of a glanded meal representing your best production, again with a mild cook but in the 400 ppm level free gossypol, we will test it and then the results will be sent back to you. Thank you.

H. B. COOPER Dr. Carter, I have one question. One thing that bothers me--we speak of low gossypol. Theoretically, if we have all of the genes together, we have gossypol-free seed or meal. When we talk about low gossypol, are we talking about the truly homogenous recessive condition which should be gossypol-free or are we talking about segregating populations in which some of the glanded genes still reside in the populations? Looking at quite a number of the analyses of pure glandless cottons, you always see a figure with a decimal value such as 0.006, indicating free gossypol. What about our techniques, are we detecting gossypol or are we detecting something else? Is this true gossypol, or what is it? I am a little confused on the issue. Perhaps someone could elaborate on this.

M. E. CARTER Wilda, do you have any comments you care to make on that?

W. H. MARTINEZ I think there very definitely is a problem with the gossypol methodology. There are other pigments that will, under certain circumstances, particularly where the gossypol content is extremely low, analyze as gossypol if the methodology is carried out in a routine manner. If care is taken to examine the full spectrophotometric curve, you can then identify the fact that this, indeed, is not gossypol. This is part of the problem. But I think you raise a very real question--what should

we be aiming for and what are we really talking about? Will we be satisfied with low gossypol or are we interested in glandless?

J. FOSTER The question Dr. Wilcke brought up about the 100 ppm versus the 450, I would like a little clarification on that if possible to see if we are beating our heads against the wall trying to get a product to compete.

M. E. CARTER I think that is a good question. I think in your opening remarks, Dr. Wilcke, you talked about 450 ppm of free and then you come back today and say that should be both free and total. Do you have a comment?

H. L. WILCKE The question of the 100 ppm of free gossypol is based upon feeding results with laying hens. At that level, it can be fed quite safely. The question of whether we have that or 450, or whether we are beating our heads against the wall, I think is a question the breeders have to answer. I would like to hear from Dick Phelps on this question. I know he has thought about it, and, Dr. Cooper, while you are talking about this, I would like to hear an expression from you, too, as just where you think that level ought to be.

R. A. PHELPS I think you will have ruled out a lot of opportunities if the total gossypol level in glandless products is allowed to be as high as 450 parts per million. A preferable level would be somewhere between 0 and 60 ppm.

Dr. Wilcke, yesterday you reviewed the tangible and intangible aspects of the ruminant market for glandless or low gossypol cottonseed meal. I believe you stated that the main opportunities would probably be in pre-ruminant feeds, that is, prior to development of a functioning rumen, and in calf milk replacers. I wonder if you would comment on what I think is a real and practical problem of feed manufacturers, that is the resistance to go to the expense of installing separate storage tanks, conveyors, etc. to handle a new ingredient such as glandless cottonseed meal. Most of the glanded cottonseed meal is now consumed in ruminant feeds. Isn't it likely that a lot of glandless meal will be used in ruminant feeds simply because nonruminant feed use will dictate purchase of glandless meal and feed manufacturers will not want to go to the expense of putting in separate facilities for both glandless and glanded cottonseed meal?

H. L. WILCKE Yes, I agree with you. This sounds like a trivial thing but, as Dick says, in the feed industry, it is quite often a decisive factor on whether you use a certain ingredient or not because of the cost, space or whatever of adding those additional facilities to handle the additional ingredients. And, certainly, I was a little bit surprised, but the glandless did compete very well in some of the ruminant rations.

E. W. LUSAS Dr. Wilcke, are you talking about 100 ppm gossypol in the rations or in the meal?

H. L. WILCKE In the cottonseed meal.

E. W. LUSAS What level of gossypol would you have in the ration that you feed animals?

H. L. WILCKE At that level you could feed it up to 20 percent, the level would be 20 ppm in the total ration.

E. W. LUSAS Then, if you are doing this with meal from current glanded varieties, you are talking of 100 ppm of free gossypol rather than total gossypol. Right?

H. L. WILCKE Free is right.

CLOSING REMARKS

By Wilda H. Martinez

I believe the most pertinent remark that I can make at this point in the close of this conference is where do we start? How do we overcome the concern, and perhaps even the fear, of the producer toward growing glandless cottonseed? How do we obtain the necessary regulation and provide the incentive to assure the purity of glandless throughout the system? How do we provide glandless cottonseed products in the marketplace in appropriate quantity and at reasonable price levels. These are the questions which I believe that we came together to discuss. We have listened intently over the past two days to the information provided in each of these areas. And we have identified the concerns and the advantages. We must now begin to devise the answers.

In closing, I would first like to express my thanks to you, the participants. The steering committee did an excellent job in providing the framework for this conference, but it is to you, the participants, that we owe any measure of success that this conference may claim. I know Phil Miller joins me in thanking our General Chairman, Mr. Garlon Harper, Miss Shirley Saucier, Conference Coordinator, and Dr. Lynn Jones and those members of the NCPA staff who did so much to make this conference a success. Also, I would certainly be remiss if I did not thank all of our chairmen and speakers who provided us with such excellent presentations.

DISCUSSION

W. H. MARTINEZ At this point, I really would like to open it up again for discussion. Does anyone have a suggestion, a thought, a means of approaching the answers to any one of these questions?

E. W. LUSAS I would like to ask the people around the room when was the last time that somebody came by and offered you a million dollars? Anyone? Alright, how about ten dollars? Anyone ever had that experience? Some one called you in the middle of the night and said"I like you, I am going to send you ten dollars in the mail tomorrow?" No? That's the way our system works; isn't it? The market is not going to come to you. If you really want it, you will not only have to work for it, but will have to fight like the dickens for it! During the last two days, we have heard there are two markets to be pursued, feeds and human foods. Does the industry want to fight to get these markets? The people who are weak at heart shouldn't even try, because it is going to be a very difficult fight. Earlier, Jack Whetstone and Carl Cox said that since they started the program, dozens of concerns and problems which had not been anticipated have come up. Just like Winston Churchill said at the start of World War II--all he could offer the British was sweat and tears. If we go on to develop these markets, we are going to find dozens of additional concerns to delay us, frustrate us, discourage us.

The question is "what are we going to do; do we want to go for these markets or not?"

A humorist named Ogden Nash wrote a limerick that said "The difference between men and boys is the price of their toys!" That is what we have here, something potentially big but it has got high risk factors. Are we going to try for it? Naturally we are going to use our heads--we are going to get as many answers as we can through research to reduce these risks. But we cannot look to the soybean companies to provide the market for us. No more than 2 or 3 percent of the soybeans grown in the United States are converted to human foods. I do not know what the exact figures are, and Dr. Wilcke can help me out on this, but if one were to convert all of the current human food markets that soybeans have, by substituting cottonseed, it would not absorb more than 25 or 30 percent of the current cottonseed meal supply. What you are dealing with is a very structured market. You are going to have to identify your customers' unmet needs just like anyone else starting a business. Find situations where you have an advantage, cost wise, functionality wise, nutrition wise, and develop these areas. You are going to have to compete for the market. This is what life is all about, and we should not be discouraged. But, we cannot make broad decisions. The marines say, "all we need is a few good men." What we need is a few good ideas and like one of the speakers said earlier "Let us start small and build a market." To summarize this in a few words, we should select a few key areas, set our sights for those targets, and push on, rather than try to make changes across the whole industry.

J. FOSTER That is my point exactly. He alludes to the royal we, and we in the seed breeding business, we in the seed sales business, we in the oil mills, and we in the other applications are trying to market something to the farmer and get something back from him to market to the public. We each have our own interest. As a business man, I am not going to let out all of the ideas and plans that I have to a meeting like this. Perhaps if I were democratic enough and benevolent enough and sympathetic enough, I should share in order to get this thing moving in the industry. I definitely have plans on what niches I am going after, and I also know the time lag that is involved to get enough of the product available.

I talked about the real farmer yesterday and the individual we have here, Mr. Mason, at his own expense has bought the seed, has raised it, and has put it in a warehouse to hold in hopes that there will be a market for him to move it. Here is an individual, a farmer, at the very base level who is taking a stand and doing something because he feels glandless is going to pan out over the future. Others of us are developing in our own ways to our little niches. The giants of the industry, the Anderson Claytons and other people like this will be interested when glandless becomes big enough for them to be involved. Otherwise, their Board of Directors will not allow them to enter. That is good and that is bad. It is bad if you look at the wide spectrum of getting the cotton industry involved. But there isn't the market yet to do it. As Dr. Lusas has pointed out, very adroitly, you have got to start a some point. I am very reluctant and other people that are actively pursuing glandless are reluctant to say exactly what their plans are because this may arouse the interest of someone else. We are all selfish in business and this is possibly not the way we should be in this application, but it is very real and that is why I get back to the we. We is me at this

point and I wish I had an oil mill, I wish I had a battery of gins, I wish I had everything, but I do not yet--wait until next year.

E. W. LUSAS If I could make another comment as to "we." "We" always comes back to "just us." In the long run, the best helping hand is still the one at the end of our arm.

A. L. VANDERGRIFF As one who has had a long career in breaking barriers, I would like to offer a word of encouragement. I think that we are at the point that whatever you might do or say, you cannot stop this. It is going to go anyway. It has, as we have said, all the good things going for it. We are fortunate in being able to have this group which I think we say is "we." I do not know exact who "we" is but it is a lot of very capable people who can offer a lot of positive help, a lot of checks and balances. "We" has a lot of things he has warned us about and how we can get into trouble, but these things are not going to stop him. It is not going to stop. I would like to say one more time that I would like to see us leave this meeting with a little more of a formulated plan as to what "we," this group, is going to do. Some more organized effort to pursue glandless. But whatever we do, we are not going to be able to stop it. I am sure we will not, and I would like, again, to thank this group for inviting me. I would like to congratulate this group for getting together. It took a lot of work. I cannot see how this kind of organized effort can possibly be stopped.

C. COX I have had my time at the podium but he really got me excited. That is a challenge--I would like to make this as a motion to the floor. I think we are rather official, we have been listed in all kinds of journals, etc., and it is an open meeting. I would like to make a motion that we take the Steering Committee that has been formed--it was not formed in the deep of night--a lot of thinking went into it, and have the Steering Committee that formed this program be a continuing committee to stay right on the subject we addressed ourselves today.

W. H. MARTINEZ We have a motion on the floor. Do we have any comment on the motion? Would we like to take a vote on the motion? The motion has been seconded. All in favor? Opposed? The motion has carried.

J. FOSTER As far as I know, and I would like to have some clarification on this, the only product that is approved at this point is the cotton nut or the Tamunut like product. I would like to see the National Cottonseed Products Association or whoever develops a program to start getting more of these products okayed. This would overcome the objection raised by the food industry. If industry can have more okays, then they will start experimenting and developing products that use cottonseed. I would like to help out and see that someone is responsible for pursuing such a regulation.

W. H. MARTINEZ I would like to make a comment on this point. I had a private discussion with Dr. Stillings on this point. He is the gentleman who made the statement that you are eluding to. There is some concern on interpretation and I wish Leroy Schilt were still with us so that he could aid us in this interpretation. What is, and has been, approved is clearance for hexane extracted cottonseed flour. This regulation does not say glanded or glandless and carries the restriction of .045 percent gossypol. Now, whether this can be considered as full clearance for glandless cottonseed flour or not is a matter of interpretation, and I think you are quite correct. Someone must assume the responsibility of

clearing this with FDA, or at least providing in writing an interpretation.

C. D. RANNEY I have a couple of questions that I would like to get some answers to. I have heard it said a number of times that gl_2gl_3 gives gossypol-free cotton. I have heard Dr. Bird mention, I believe I heard him right, that in some of his material that this was not exactly so. In some genetic backgrounds, we may have a problem. From what I can gather, the current products that have been registered from glandless cottons also carry a rather high tolerance, 450 ppm. My first question is, are these cottons, in fact, gossypol-free? My second question relates to Cooper's comments. I believe I heard someone say earlier that with the official testing procedures of AOAC, the variation is plus or minus 20 ppm on free gossypol and plus or minus 50 ppm on total gossypol. My third question is this. How are we going to find out where we are with this kind of variation? We need, desperately need, some better test methods in order to give the people that are producing these cottons the means to know when they have a glandless cotton; whether it is gossypol free or not. I think this is one of the researchable problems that you need to be concerned about as an outcome of this meeting.

H. B. COOPER Yes, I agree with you, and the thing they have pointed out here is what really confuses me. Theoretically, we talked about the small gl combination as being gossypol free, but our technique does not assure us that it is. And then, there are these other comments which indicate that if you put glandless genes in this or in the other background, they are going to differ in response. Well, what differs about them? I mean, it seems that we are going to have to develop and insure purity of these two glandless genes. And then we have to have a test precise enough to tell us really what these genes do. What are we getting? Is there a real background difference? Are we getting some type of mechanical contamination or mixtures in these that are providing confusion to us. I think Dave's very right. We need to develop some of these techniques and get us a zero base, and once we get that, then we can deal with these differences in germplasm, etc. Then we can rule out these mechanical mixtures or segregating populations. But until we do, we really do not know where we are.

W. H. MARTINEZ Dr. Cooper, can you assure us as a breeder, that you are not dealing with mechanical contamination or environmental response?

H. B. COOPER I can assure you that we are not dealing with mechanical contamination or with segregating material. The lines are true-breeding for glandless. Now, back to how these things respond under different environments. We still do not know. We do know that in the glanded material that environment does play a role in the level of gossypol. We can detect that within relatively uniform environments in San Joaquin Valley. If we move about in the San Joaquin Valley, we can detect differences in our glanded cotton, gossypol would be down in one place, up in another, intermediate in still another. We have not detected this with the glandless that we have moved around. We get this same little bit of gossypol in our glandless cottons. We get that .003 percent or .004 percent level or something of that sort. We do not have a zero base. I have heard others comment that truly we are not measuring gossypol by our present techniques.

P. J. WAN Since we have spent a lot of cotton growers' money to study the color

problem, I feel we should try to answer some of the questions raised up to this point. With the financial support from both Cotton Incorporated and the Natural Fiber and Food Protein Commission of Texas, the Food Protein R&D Center at Texas A&M University has undertaken the investigation of pigmentation problems associated with glandless cottonseed for the past several years. Two years ago, we demonstrated that residual pigment glands were the major cause of the discoloration problem in glandless cottonseed and LCP deglanded flour. Through careful preparation (manually eliminating contaminated glanded or partially glanded seed), a small batch of gland-free cottonseed flour was produced which had a light color that has never been observed before. If we chose commercial soy flour as a standard sample, gland-free cottonseed flour had a color either comparable to or better than that of soy flour. Next, we turned our attention to the question, "Is gland-free cottonseed flour gossypol free?" Unfortunately, there is no absolute way to answer this question. Therefore, we went through the following three approaches:

(1) to examine the gland-free cottonseed flour microscopically

(2) to chromatograph the crude extract from the gland-free cottonseed flour on paper

(3) to determine the gossypol content of gland-free cottonseed flour by using official AOCS method

The results indicated that gland-free flour should be considered as gossypol free. Meantime, we also wanted to know how good the AOCS gossypol method is. To achieve this goal, we used the same AOCS gossypol method to test several samples containing no gossypol, such as, soy, sunflower, peanut, wheat flour and diatomaceous earth. The results indicated that the selectivity of the AOCS gossypol method is quite good. The same results showed that the lowest detectable level for total gossypol method is around 50 ppm and that for free gossypol method is around 30 ppm. Obviously, a better method which will give more sensitive and reliable gossypol determination is definitely needed.

G. A. HARPER I feel that there are two comments which I should make at this time. The question of FDA clearance of glandless cottonseed flour as a human food has been raised. I assure you that the NCPA staff will follow up on this interpretation. Food additive regulation 21 CFR 172.894 is somewhat unclear in that it refers to "cottonseed" without reference to "glanded" or "glandless" for the solvent extracted flour. Perhaps, the petition submitted for approval must be studied first.

I want to make one other comment. In the session this afternoon, especially since these summaries have been presented, I detect some frustration or disappointment or even negative viewpoint that this conference may have not accomplished as much as it should have. I would always be in agreement that a conference of this type cannot immediately resolve all of the questions. I think a great deal has been accomplished. I feel that a great deal more remains to be done, and I believe that it must be done. I was very glad to hear Mr. Vandergriff say that glandless cottonseed is going to come, that we cannot stop it. I feel that way and I think that what we have done here, at this conference for the first time, is that we have brought all of these diverse elements together and they have put their problems out on the table. I do not find it surpris-

ing at all that we have come to the conclusion of this conference without having all of the approaches wrapped up in a neat little package. We are beginning to understand each other, and I think that when we do, we as all segments of the cottonseed industry and the consumers of cottonseed products, will be able to work together and to resolve these questions. I personally cannot join in any pessimism at this point because I feel that we have accomplished a great deal, not as much as we had hoped that we would accomplish but I think that we have accomplished so much that this has been one of the most worthwhile conferences that I have ever attended in cottonseed work.

B. ALFORD I have not heard something said at this conference that I really think needs to be said. Because at the Texas Woman's University our staff and graduate students have had the largest human feeding experience on a practical basis in real life situations -- cottonseed is a very acceptable food for human beings. You know those of us who are directly involved with the critical evaluation of foods, look at it very differently than the average individual. It may take us a month or so to sell cottonseed in some instances because it may look a little different. You have one disadvantage that people do not think about human beings eating cottonseed, but as soon as we have overcome that barrier cottonseed is acceptable. We have served cottonseed foods at all kinds of social and experimental situations and have found very many highly acceptable foods whether we have told people that cottonseed is in that food or not. And, I feel that you ladies and gentlemen who are a part of this group in considering glandless cottonseed, do need to know that in broad-based experience with human beings the acceptance of cottonseed is very good. I do not know anything about animal nutrition and how well they accept it except for what rats show and we are not trying to feed rats, but I do know for human beings, it does have a very great potential equal to any other plant proteins that we might try to feed.

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